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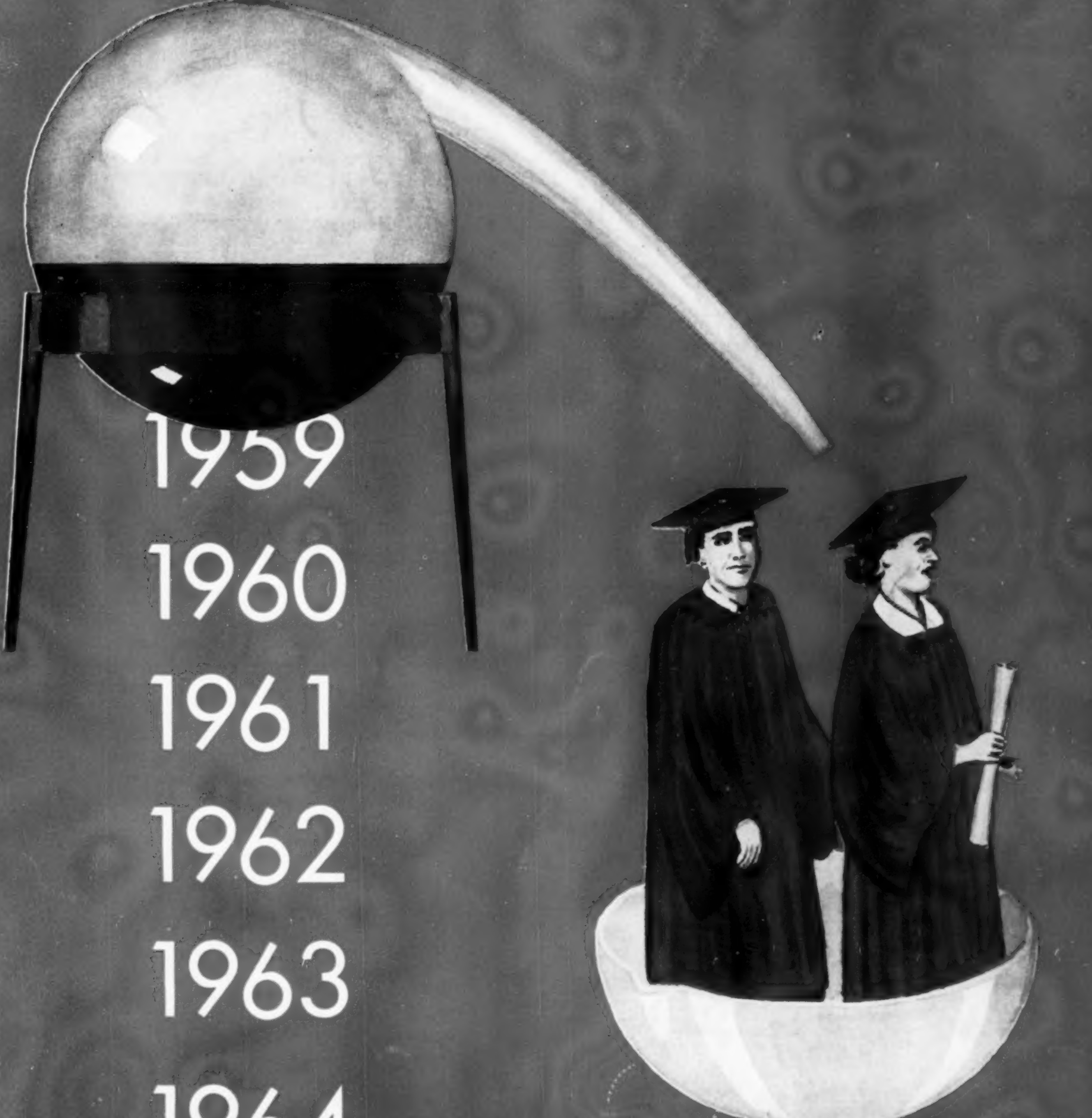
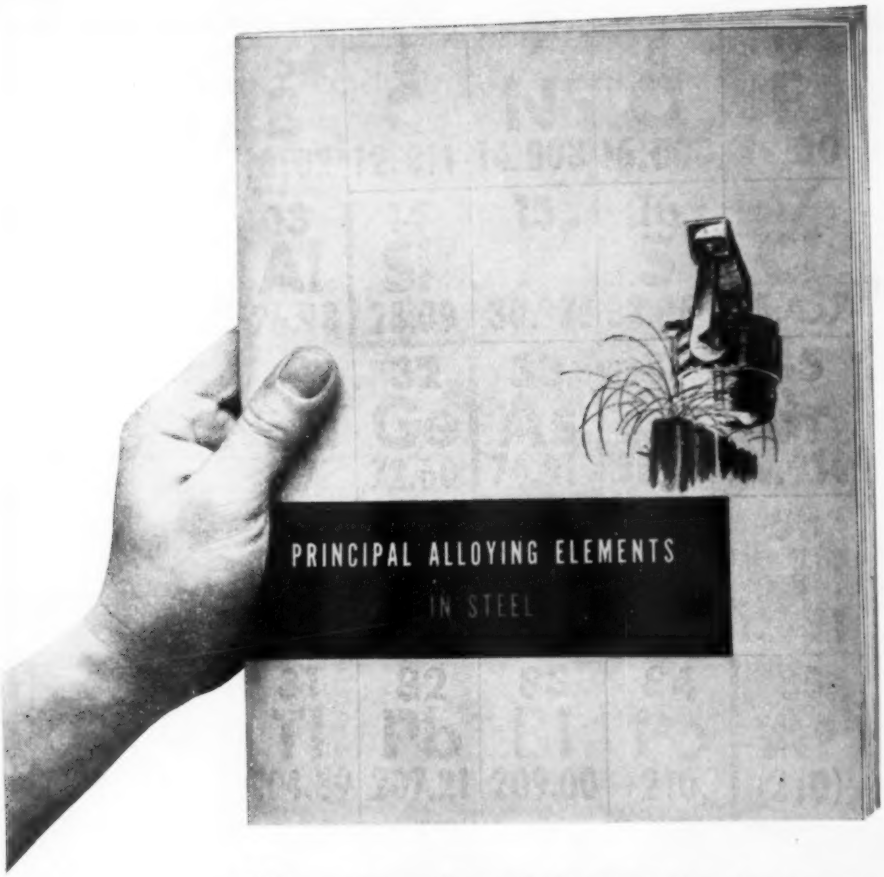
MARCH 1959

THE SCIENCE TEACHER



JOURNAL OF THE NATIONAL SCIENCE TEACHERS ASSOCIATION



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THE SCIENCE TEACHER

The National Science Teachers Association is a department of the National Education Association and an affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction and later expanded as the American Council of Science Teachers, it merged with the American Science Teachers Association and reorganized in 1944 to form the present Association.

Volume 26, Number 2 **March 1959**

Editor's Column

Two to three thousand of us will soon be going to Atlantic City for several days of conventioning on the theme, "Science Education for America: An Appraisal and A Look Ahead."

I just hope we're not going there looking for a special brand of science teaching which would be "good for Americans" as opposed to something ungood for us but good for Cambodians, Chileans, Frenchmen, Russians, or New Zealanders, or vice versa. This is not what the committee meant when they established the theme.

Whether or not we go to Atlantic City, we might ponder on what *is* good science education for Americans —and for all other people all around the globe. Here are a few suggestions (merely as reminders).

—that which provides direct experiences with the methods, procedures, and attitudes of practicing scientists.

—that which implants useful information and develops command of fundamental concepts and principles.

—that which helps dispel superstitions and unfounded beliefs.

—that which reveals the functions of scientific knowledge in personal and social affairs such as:

a. the biology of food supplies, sanitation, personal health, and others.

b. the relations of energy supplies, machines, automation, communication, and transportation.

c. the relations of scientific or technological developments and social problems like air pollution, radioactive fallout, and noise.

—that which helps us understand the world we live in, both for the purpose of intellectual satisfaction and for the purpose of increasing our control of the environment.

—that which provides inspiration, zeal, and opportunities for each youngster to achieve his full potential in personal growth and career development.

I can't see how we can do a real good job of teaching science (at 2nd grade, 9th grade, or in biology or physics) unless we have some carefully thought-out objectives or intentions firmly fixed in mind. We've got to realize that "science" is not merely a bag of tricks, or being first with larger satellites shot farther into space; on the other hand, I don't see it either as a neat package of information to be swallowed pleasantly (or with difficulty, if you insist on "toughening" the curriculum).

Science education for America—for American children —should be geared to the fundamental purposes of education in the American democracy. Central purposes are the maximum development of each individual and the meeting of our society's needs—the preparation of literate, independently dependable citizens. The teaching of science as one ingredient in this kind of education is a difficult, demanding task. It calls for wise planning artfully carried out. A presentation of problems, issues, and examples relating to such science education is the goal of the Atlantic City convention.

Robert H. Carleton

THE SCIENCE TEACHER

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Readers' Column

The following letters provide an interesting debate on this important problem, and we thought the readers would find it of interest. *Editor.*

Newton's Laws

Unfortunately there seem to be aberrations even in discussions of "Aberrations in Discussions of Newton's Laws." The excellent article (December 58) by L. W. Phillips, decrying fuzzy thinking by physics teachers, had at least one fuzzy mote in its own eye.

Dr. Phillips doesn't like mass defined as "quantity of matter" because it leads into the blind alley of defining matter. Apparently he prefers to define it with the one word "inertia," although this leads into the even shorter vicious circle of defining it as mass.

The thing that I lament is the reluctance on the part of teachers to admit that some part of their subject is indefinable. The fact of the matter is that "mass" is incapable of being defined in basic or ultimate terms because it *is* the ultimate term. This is true for any basic concept. Webster defines "time" as measured duration, and "duration" as continuance in time, so circular definition is found even among lexicographers.

If the definition of any word is pursued far enough, it either turns around into a circle or reaches a basic term that cannot be defined except in terms of personal experience. As Louis Armstrong says of jazz, "If you gotta ask what it is, you'll never know."

Harold R. Horn, M.D.
Lincoln Clinic
Lincoln, Nebraska

I found the article by L. W. Phillips on "Aberrations in Discussions of Newton's Laws" in your December issue most interesting. The clear and incisive manner in which the basic concepts of Newton's Laws are presented testify to Dr. Phillips' deep knowledge of the subject. Some of his formulations are unquestionably superior to those in current use in high school physics teaching.

However, it is important for Dr. Phillips and other college teachers of physics to pay sympathetic attention to some of the problems of high school physics teachers. We deal with young people who generally have little or no background in some of the concepts we must develop. It is therefore frequently impractical to state certain ideas rigorously, in a manner that would please a college teacher, but which the pupil in the class just won't understand.

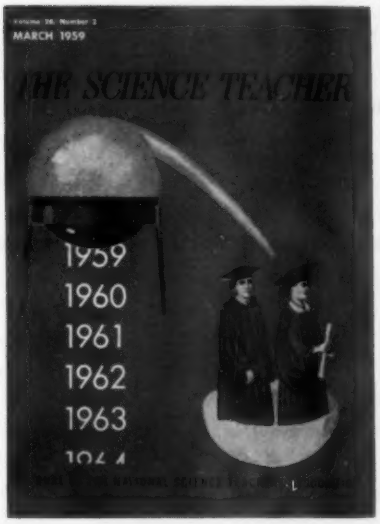
For example, it is necessary to develop some idea of the meaning of mass at an early point in the physics course. Density will be defined as mass per unit volume. Therefore we must explain mass. But if we define mass correctly, in terms of inertia, it also follows that inertia must first be taken up. This in turn means that the idea of density must wait until a later time. But certain desirable organizations of the subject matter in physics consider density very early. Nor does it follow that if Dr. Phillips' way of defining mass is adopted, that the pupil will know what the teacher is talking about when he defines density in terms of a mass that hinges on inertia.

It is possible to make an understandable presentation of mass and weight on the basis of elementary experiences which the pupil has had. It is the function of the high school teacher to introduce the pupil to his first idea that there is any difference at all. It may have to be done on a passing reference in the course of a general discussion. In a textbook it may have to be done in a paragraph or two, with ample illustration to make the differences clear.

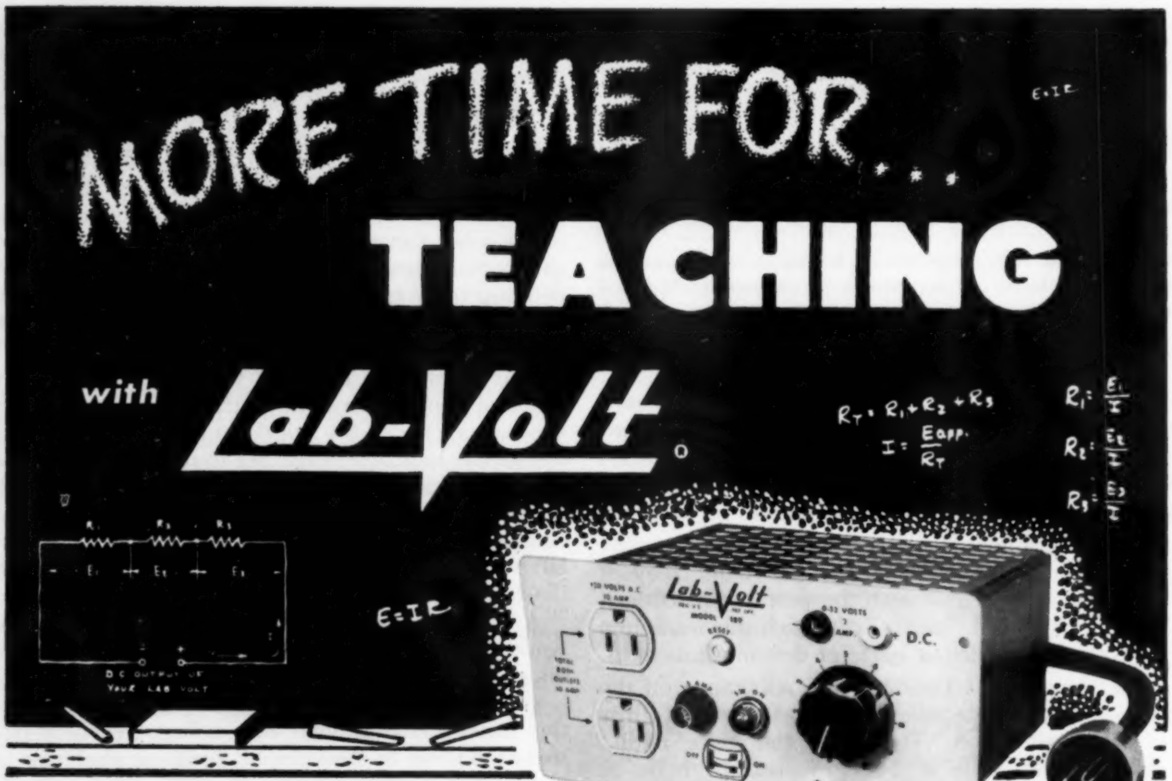
As a practical matter, ways of cooperation must be worked out by high school and college teachers in which interplay of their different approaches help to create superior teaching methods. In the course of this interplay, it is vital that college teachers pay some attention to the complex teaching problems of high school teachers, while the latter should devote

(Continued on page 142)

THIS MONTH'S COVER . . .



Years of intensive effort with essential ingredients, culminating in the attainment of greater scientific knowledge, symbolize here the theme of the upcoming NSTA Convention at Atlantic City: "Science Education for America: An Appraisal and a Look Ahead."



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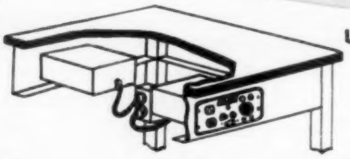

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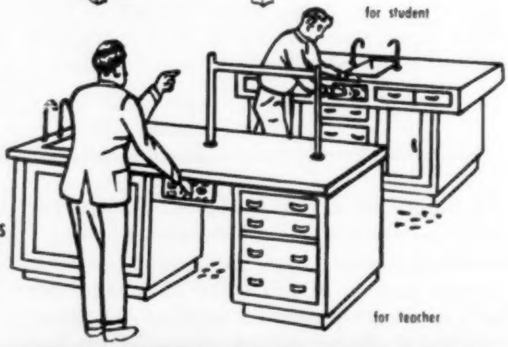

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The Horace Mann Science Program

A SUMMER PROJECT

By HARRY H. WILLIAMS

Assistant Principal, Horace Mann School, New York City

MANY of us in secondary education have been struck repeatedly in the past months by the almost continuous plea from top management in American industry and business for able, young people who are unfettered in their approach to new problems, whose education and background stimulate original thinking in new situations; in short, people who will provide the intellectual leadership for the scientific—and perhaps other—aspects of our society in the years ahead.

Granted that the school is the most important of the agencies basically responsible for producing the nation's scientists, it seems logical that it should provide opportunity for intensive work by qualified students at the time when space and teachers are available. The strategic place in which to initiate such a program seems to us to be the secondary school, and as we considered our own situation more than a year ago the strategic time seemed to be the summer months.

While creative endeavor should certainly be a part of the regular science program, it is our experience that the routine demands of a rich curriculum limit the amount of both time and energy that teachers or students can devote to special project work. Then, too, there are the limitations of available space.

As we have looked back upon the experiences of last summer, we have become more and more certain that a period of time such as that available during the summer when academic pressures are relieved is a most favorable time for research-type programs. Indeed, if, as seems likely, schools continue to provide during the

regular year more and more challenge to the talented through honors courses, the Advanced Placement Program, and other special course programs, the summer months may well become an even more strategic time for special programs of non-credit nature aimed primarily at creative endeavor. The hope is that such programs will attract and stimulate the really exciting and excited young people whose opportunity to undertake a self-designed experiment in physics, chemistry, or biology is now restricted to the cellar, the garage, or the kitchen sink. If each program could just find and stimulate one such person to undertake a career in science, the contribution to society would clearly be far greater than the small amount of money required for its support. Those who do not continue in science may, at least, be open to the needs of future scientists.

Background of the Program

Nineteen students under the supervision of two faculty members participated in last summer's program at Horace Mann. They were chosen from more than twice this number who applied when the opportunity was announced early in the 1957-58 school year. The selection of students was based upon interest, over-all academic achievement, objective test data and teacher judgment. It was felt important that participants should have no academic deficiencies to be made up during the summer since such work would interfere with the proposed program. No prerequisites were set in terms of courses. As it turned out, the students selected were at the time of their selection in the eighth, ninth, tenth or eleventh grade. Accordingly, their last science course was earth science, general physical science, biology, or physics. None of the students had yet had a course in chemistry. In most cases, the project chosen was an outgrowth of the last science course taken.

Both of the faculty members who supervised the program had already demonstrated their enthusiasm for research-type projects as part of the work of their regular classes. One had his major training in the physical sciences and the other in the biological sciences. Available for consultation was a third faculty member with a background of industrial research experience who was teaching science courses in the regular summer classes which were also in session while the special science program was in progress.

Following his enrollment in the program, each student met with his faculty advisor periodically during the spring of 1958 and outlined the project on which he wished to work. Each student was expected to begin library research and to do other preliminary work on his subject. An attempt was made to anticipate material needs so that students, in most cases, were able to start immediately on the construction phase of their projects on opening day, June 23, 1958.

Several unsolicited gifts were received from parents and alumni shortly after the program was announced. The outline of the proposal was submitted to a number of corporations with a request for support. Altogether, the sum of $2050 was received from these various sources. These funds covered a large proportion of the cost of materials purchased for the various projects and also of general equipment needed such as a microtome, sterilizer, and incubator. Other costs, including faculty salaries and the cost of lunches for the students, were met by charging each participant a fee.

The Summer Program

Faculty members served as resource persons to whom the participating student could turn for help when need arose. No class instruction was arranged in advance. During the summer, one group did ask for and receive a number of lectures by the faculty consultant on certain phases of organic chemistry which related to a number of the projects. Members of the group decided that these would be helpful and the faculty adviser concurred.

From the beginning, it was felt that interferences with work of a student on his project should be held to a minimum. Accordingly, group field trips were not arranged, but individuals were encouraged to visit outside resource persons whenever special help was needed beyond that which could be provided at school. Outside agencies were used to a considerable extent. In each case, the student chose a problem which required the construction of apparatus to be used in gathering data for analysis and evaluation, and to serve as the basis for drawing conclusions. Each student was required to keep a bound notebook in which he recorded a day-by-day account of whatever he did. These were examined periodically by his faculty adviser. The entire group convened daily in the early afternoon to provide each student an opportunity to describe his project and to give a progress

report. In this way, every student was able to report to the assembled group three times during the eight weeks.

The manner in which the projects ramified beyond the confines of the school is best illustrated by the example of the boy who chose to work in the area of blood clotting. His correspondence with Dr. K. N. VonKaulla of the Medical Center staff of the University of Colorado led first to a meeting with this authority and then a few weeks of training at the above university just prior to the opening of the summer program at Horace Mann.

Another boy's inquiries in the area of plant tropisms led to an invitation to work in this area during the summer at the Josiah Willard Gibbs Laboratory at Yale University. All concerned felt that he should accept this invitation and he did so. He has already enrolled in our next summer's program at Horace Mann and plans to continue along the lines of last summer's work at Yale University.

Projects undertaken and, in most cases, still in progress during the 1958-59 school year are listed below:

1. A study using paper electrophoresis of similarities in the blood of different animals
2. A study of the effect of certain substances on the fibrolytic process
3. The effect of hormones and vitamins on maze-learning in rats

*4 & 5. Effects of stains upon animal tissues

6. Reactions of bacteria to antibiotics
7. A study of gas analysis through the use of resonant frequency

*8 & 9. Astronomical observation including the construction of a six-inch Newtonian Reflecting Telescope

10. Chemical analysis using a concave diffraction grating spectroscope
11. Telemetering the electrocardiagram of a patient while he is active
12. A study of gaseous discharge and its effects upon the germination of seeds
13. A study of radioactive fallout using a decade scaler
14. A study of vertical take-off using a circular wing and motor-driven propeller
15. A ternary system relay computer
16. Simulating animal characteristics in a machine (Machina Speculatrix)
17. A modified Van de Graff Generator
18. A study of radiation effects upon the Drosophila

* Separate projects.

19. A study of the receptability of soils of different phosphorus content and phosphorus fixing capacity to a high concentrate fertilizer in regard to the growing of plants.

In anticipation of the fact that most of the projects begun during the summer would not be completed, the Science Department had asked for and been granted the use of a room to be designated as the "Science Project Room." At the end of the summer the partially completed projects were transferred to stations set up in this room. Since this room was formerly a science room, it already contained many of the needed laboratory facilities. During the present school year other special equipment has been added. It has also been possible to relieve one member of the Science Department of some of his regular teaching load so that he can devote this time to the supervision of the project room. Progress on the projects had been at a much slower pace during the regular year.

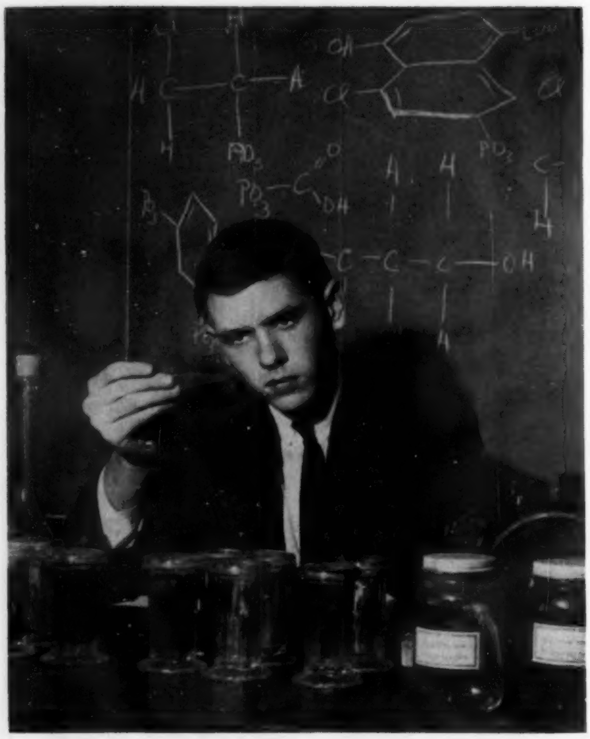
Preliminary Evaluation

Without exception the faculty and students involved are of the opinion that their initial program was a real success. Confirming this opinion is the fact that six of the students already have applied for the opportunity to repeat the experience next summer. The teachers are also anxious to continue the program. One of the faculty members reported at the summer's end:

> "The reports of the boys (written at the end of the session) indicate they have learned something very worthwhile: the art of objective and positive criticism and reporting. There is none of the clumsy, childish, adolescent foolishness so often the joy of young people. They would not have written such reports as these two months ago . . . I believe it is significant that those in the group desire to continue to a man. I am pleased personally to note that their self-motivation has never diminished from the first day to the last. Their enthusiasm, in the main, is greater now than when we started . . . In short, my boys and I consider the program a rousing success."

Typical student reaction taken from one of the student's final reports is as follows:

> "The most important thing that I learned this summer is that experimental science does not follow one set pattern. I have found out that in my type of work one and one does not always equal two. Facing the many varied problems of my project has developed in me a greater respect for science . . . I think that the Summer Science Program has served in creating in me a greater



Bill Schwartzmann studies the cell structure of plants and animals.

interest and insight in science. I have found that research is not simple and straightforward, but that it consists of many obstacles all of which have to be surmounted."

It can be said with confidence that the program has had an upgrading effect upon the school's Science Department. The faculty members involved attest to the in-service training effect it has had upon them. They look back upon it as a most valuable experience. The acquisition of a special project room with special equipment for this type of work has been another direct benefit to the department.

A measure of the success of the program is seen in the fact that enthusiasm of the Science Department has spread to the other departments of the school. These departments have suggested to the school's curriculum committee their willingness to offer special non-credit programs of a somewhat similar nature next summer in historical research, dramatics, creative writing, motion picture production, and the French language. The committee is presently investigating student interest in these areas and expects that offerings with an emphasis on creativity and research will materialize in at least one or more of these fields.

Visual Aids for Teaching Bacteriology

By WILLIAM S. GREEN
North High School, Denver, Colorado

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA, and sponsored by the National Cancer Institute, U. S. Public Health Service.

THE PURPOSE OF THIS PAPER[1] is to demonstrate ways of surmounting the limitations of equipment, space, and time in helping students do effective individual and group work in certain bacteriological studies. Today, as never before, this is important. The exercise, techniques, and equipment suggested motivate students in achieving critical thinking objectives so essential to experiences in scientific inquiry.

Visual aids which closely resemble actual Petri dishes containing nutritive media and live organisms are used. The simulation technique saves time and equipment. An experiment that involves hours and days can be condensed into one fruitful period of accomplishment.

Historical Background

Louis Pasteur's momentous work which proved bacteria to be the causitive agents of fermentation and disease was the opening wedge for all later studies of germ-caused infections. Robert Koch also set a pattern in bacteriological technique. His four steps in the investigation of disease are still used today. He is famous too, for his work in the laboratory culture of bacteria, particularly his discovery of various types of culture media. In this connection it is important to remember that the discovery of solid media was an outstanding landmark. This opened up a whole new area for fruitful study. Observing the colonial characteristics of bacteria, what they did to various kinds of media, and how the colonies appeared was indeed significant. The study of millions of organisms that composed a single colony on the surface of solid media made a spot easily visible to the naked eye. The discovery yielded an enormous amount of knowledge that is expanding and developing to this day, and offering many challenges.

Materials and Methods

The study of bacteriology as a unit or a part of the high school biology course presents numerous but challenging problems. These problems can be considered mainly with reference to equipment, time, and space limitations. The teacher with enthusiasm and a good working knowledge of the subject can do wonders with a unit in bacteriology. It is not only satisfying to teach but is richly rewarding to the students. Pupils show a genuine and strong interest in bacteriology. That makes teaching it a real joy. A good way to introduce the subject is to use a large Petri dish with simulated blood agar having numerous "flourishing" colonies on it, some of which are deadly pathogens! This exhibit is dramatic enough to arrest the attention of even the skeptics in your audience, especially if you act a little bit aloof in your initial presentation of the material.

Making up these Petri dishes containing simulated media is really quite easy. Petri dishes of any of the three standard sizes are the starting point. The "media" for these is made of scrap pieces of Plexiglass. This is an acrylic plastic manufactured by Rohm & Haas. The pieces used by the author were $\frac{1}{16}$" thick, white translucent, and closely resemble frosted glass with one exception—both surfaces of the Plexiglass are mirror smooth.

Place your Petri dish (bottom half) on the Plexiglass and draw around it with a sharpened wax marking pencil. The best way of cutting out the Plexiglass disk is to use one of the standard

[1] The writer wishes to thank Dr. Richard Thompson, Head of the Bacteriology Department, University of Colorado Medical School and Dr. Stuart G. Dunlop of that department for evaluating this report with respect to technical accuracy.

"cut off" wheels obtainable in hardware stores or from companies that sell blades and accessories for table saws. The "cut off" blade or disk is 8" in diameter and is composed of a rough carborundum-like material. Use it in a table saw in lieu of the wood cutting blade. Operate the disk about ¾" to one inch above the level of the saw table. As you "saw out" the Plexiglass disk, do it slowly and exercise caution. Play safe and do not get the blade in a bind. In fact, it is good practice to use goggles when cutting plastic.

When the disks are cut out they are ready to stain. Tincture of iodine works very well and so does orange shellac. With a little practice you will be able to simulate the appearance of agar agar in a very short time.

The disk is placed stained side down in the Petri dish but before you do this you will want to paint the colonies on the unstained surface. This is done with ordinary quick drying white oil paint. A small can may be purchased at any paint store. The colonies can be colored to resemble real colonies by using a very small amount of artist's tube colors — red, green, or Payne's gray mixed with white. Apply the tinted white with a small brush well loaded with paint. When held vertically and touched lightly a small "colony" results. Greater pressure gives you a larger colony.

You can apply spots of glue to the surface of the Plexiglass the same as was done with the paint but with this addition, put on a small amount of epsom salts, washing powder, or some substance that gives texture and character to the artificial colony. Wonderfully natural looking colonies of black bread mold *(Rhizopus nigricans)* can be made by pushing a wad of absorbent cotton into the drop of glue on the Plexiglass surface. When the glue has dried the excess cotton can be plucked away. Give the colony a "natural" look by shaping it with a tweezers. To add sporangia, dust lightly with black pepper and the job is completed.

It is fortunate that cherry red plastic resembles fresh blood agar so closely that it is difficult to tell them apart. All one needs to do here, is cut out the disks and paint on the colonies. By studying actual colonies and textbook color plates, it is possible to do very accurate work. Once these Petri dishes have been prepared they are good for all time and may be used any time.

The Petri dishes are only one item of equipment that may be used in the simulated demonstration method. The Bunsen burner, wire loop, staining solutions, slides, cover slips, and many other items of the bacteriological laboratory will also play a part.

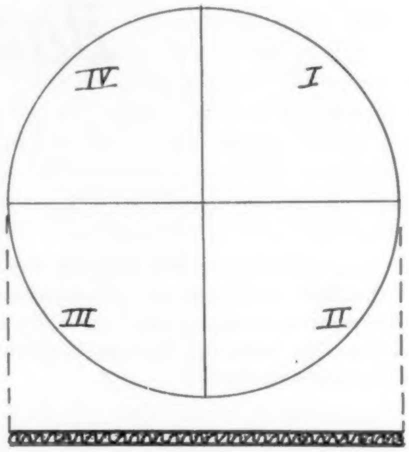


Figure 1. Cardboard disks.

With the necessary equipment on the demonstration table a student may be asked to show the class how he would go about getting a pure culture, or making a permanent slide from a certain colony. There are many manipulative problems of this nature that may be done by students or pairs of students while the class looks on. In the critique which follows, errors may be identified and corrected and when students are successful they should be praised. This is important and unfortunately is sometimes overlooked.

We do not wish to convey the impression that simulated demonstrations and experiments should take the place of actual ones. Each has its place and it is up to the teacher to make the decision which will best serve the occasion. It is important, however, for the student to relate the facts he learns from observation. He should tie things together and look for relationships. If he sees an Autoclave sterilizer or an incubator in a film or on a field trip, he should be imaginative enough to transport it to the classroom and "use it" when he gives his simulated demonstration.

A final example of a demonstration experiment using the simulation technique will serve to further clarify this method.

The Demonstration: To show how diseases are passed from individual to individual, or how epidemics come about.

Materials Needed: Simulated sterile Petri dishes with nutritive agar agar. Incubator. Simulated food.

The simulated Petri dishes can be prepared as described earlier, or even a much simplified version will serve very nicely. The simplified version is made by cutting out disks of heavy cardboard (about 6″ in diameter) and marking them as shown in Figure 1. The simulated food is made by making little "books" of heavy cardboard (Figure 2) held together with a piece of masking tape. Each piece of simulated food is wrapped in a piece of paper, just as a candy bar would be.

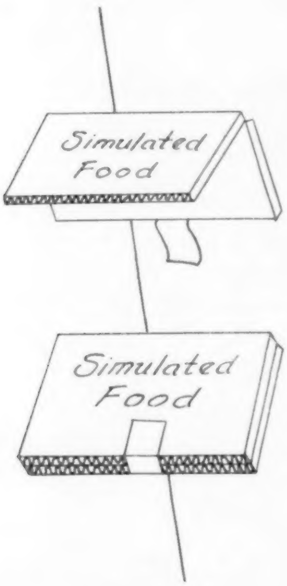


Figure 2

If the teacher wishes to actually do this experiment using real food and live organisms, the following procedure will work well. A good organism to represent the pathogenic form is *Serratia marcescens* as it has an easily recognized red colony and is a non-pathogen.

Carrot strips wrapped individually in wax paper serve very nicely. One of the four strips of carrot can be contaminated just before the students come to the laboratory.

Procedure: Select four students to participate in the demonstration and ask them to take positions in front of the class. Number the students from one to four.

Give each student a Petri dish containing sterile agar agar. Each of the Petri dishes has its area divided into four equal segments— I, II, III, and IV (Figure 1). (If glass dishes are used a wax marking pencil serves well to mark plates on the bottom and shows through the media.)

Mr. Green and students prepare Petri plates and simulated food.

All four students—raise the lid of your Petri dish and touch segment No. I lightly with your thumb and forefinger. Replace the cover.

All four students—wash your hands thoroughly with soap and water, use a clean towel. (This action is simulated.) Now raise the lid of your Petri dish and touch segment No. II lightly with your thumb and forefinger. Replace the lid.

Give each of the students a piece of food. Have them unwrap it and handle it just as if they were about to eat the food. (The pieces of simulated food are numbered one to four corresponding to the four students.) Next—raise the lid of your Petri dish and touch segment No. III lightly with thumb and forefinger. Replace lid.

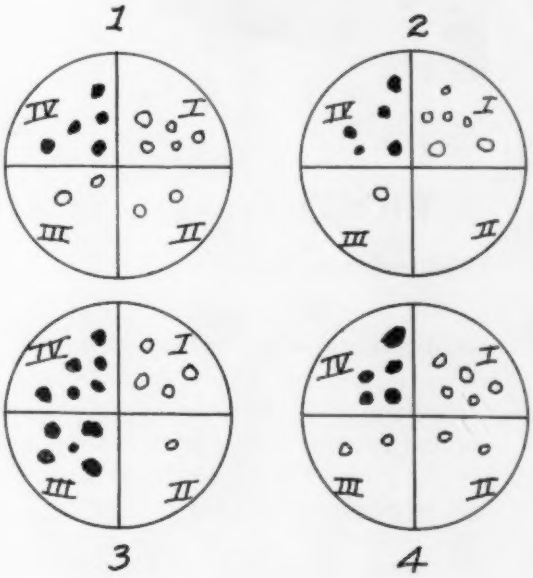


Figure 3

All four students—touch finger tips with each other using the same fingers that handled the food. Now raise the lid of your Petri dish and lightly touch segment No. IV with the thumb and forefinger. Replace the lid.

Collect the Petri dishes and incubate them for a period of twenty-four hours.

Now pass out the second set of dishes that represent the Petri plates after incubation, these are numbered one to four on the back. An additional disk can serve as a "control" plate, the purpose of which should be explained in the demonstration.

Each student in succession beginning with No. I should hold his "plate" up so the class may see the kind and number of colonies that have developed on the sections. It is a good idea to draw four large circles representing the four plates on the chalk board and indicate the colonies as follows: Harmless colonies as small circles, pathogenic colonies shaded in (Figure 3).

When the plates are studied the students will discover unmistakable evidence that washing the hands means that less or perhaps no colonies are to be found on section II of the four plates. They discover, also, that plate No. 3 has pathogenic colonies in section III. This points to the fact that piece III of simulated food was contaminated. Number 3 student now removes the tape and holds it up so the class may see the red markings indicating contamination.

The class will now be in a position to make the "write-up" on this demonstration experiment. The teacher may wish to use several questions as a check to discover if the students really understand the demonstration. Following are several questions of this type:

1. What kinds of diseases may be passed from individual to individual by food?
2. What recommendations can you make to persons having the responsibility of handling and serving food? To Mr. and Mrs. Everybody?
3. In what respects does a simulated experiment differ from an actual one? Advantages of each? Disadvantages of each?
4. What contribution has the modern practice of packaging food made to the problem of food contamination?

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HOW EFFECTIVE IS SCIENCE IN THE ELEMENTARY SCHOOL?

By SAMUEL W. BLOOM

Science Department, Monroe High School, Rochester, N. Y.

IN ORDER TO DETERMINE how effective science teaching is at the elementary level, we need to re-examine three basic purposes for the teaching of science:

1. to help all children develop an inquiring mind concerning environmental phenomena
2. to help children acquire a substantial background of useful scientific information
3. to help children acquire an appreciation of science as it affects their daily living.

Science instruction in the elementary school should be geared to these purposes and should provide ample opportunity for a great number of activities. Through varied rich experiences in science children will gain a better understanding of the "how and why" of their environment.

It is not the purpose of elementary science to identify and develop the scientist of tomorrow. It should be the purpose however to increase the understanding of growing children to live better in an age influenced by science.

Any discussion of the effectiveness of science in the elementary school begins with the teacher and necessarily includes the attitude of the administrative staff, the quality and quantity of instructional materials, and curriculum flexibility.

When the teacher is dynamic, creative, and interested in doing things, there is an outgoing science program. When this spirit is lacking, there is an ineffectual program. The greatest mitigating force against effective science teaching is the timid teacher, who is afraid of science, who is insecure and imparts this fear and insecurity to the class.

An effective science program requires, too, some basic equipment and a reasonable quantity of supplies. The teaching of science should not depend solely upon the ingenuity of the teacher working with pins, paste and paper, and the good graces of the community. Teaching science costs money and administrators should be made aware of this fact. Funds for instructional material should be available when needed with a minimum of red tape. A lack of funds, however, should not keep us from doing the maximum with the materials available. We must learn to take advantage of every community source and resource and try to present concrete materials from which our children get the experiences so vital to an understanding of science concepts.

What are the questions that children generally ask about science. Basically, they fall into four broad categories:

1. The earth and the immediate environment including the atmosphere
2. The universe: the moon, the sun, the stars
3. Living things: pets, how plants grow
4. Physical and chemical forces and phenomena.

The content of an integrated elementary science program poses difficult problems in organization. *How much—how detailed—how soon—* can various concepts and understandings be introduced? The grade placement of many scientific principles is extremely arbitrary in practice. For example, some children can understand the principles of levers as early as second grade. The principles of simple magnetism is not beyond the comprehension of many primary children. Curriculum workers tend to underestimate the potential of many of our children. Yet, of necessity, some arbitrary decisions must be made concerning the grade placement of scientific concepts at each level.

In New York State, ten organizational centers are provided for in the new *Handbook for Elementary Science* being readied for release in 1959. These are:

1. kinds of living things
2. keeping healthy
3. using electricity
4. common chemical and physical changes
5. lifting and moving things
6. energy from the sun
7. the atmosphere
8. earth and sky
9. rocks and soil
10. survival of living things.

An articulated or spiral approach is suggested by the State Education Department. Such an

approach would allow a child to have a continuing experience in each area from kindergarten through 9th grade. Appropriate activities are suggested in grade groups K-2; 3-4; and 5-6. It is suggested that local schools and the teachers concerned decide whether a particular activity should be used for 1st or 2nd grade, or the 5th or 6th grade, or others.

Let us examine one of the suggested areas to show how the more difficult concepts can be introduced as the child progresses through the different grades.

The category is *Animals Are Kinds of Living Things*. In K-2, some basic understandings which could be developed include:

1. There are many different kinds of animals; some are pets
2. Animals need water, sunlight, warmth, air, food and care
3. Changes occur in animals
4. Animals and plants need each other
5. Animals live in many places
6. Animals are useful in many ways.

At the 3-4 grade levels, more advanced basic understandings in the area of *living things* could include:

1. Animals vary in structure
2. Animals undergo physical changes with change of seasons
3. Animals often protect themselves from enemies and elements
4. Seasonal change affects the activity of animals
5. Some animals are useful; some harmful.

At the more advanced 5th- or 6th-grade levels, the basic understandings sought could include:

1. Animals vary with climate and location—there are a variety of animals in different regions of the world
2. Animals have certain habits, characteristics, and structure which determine growth
3. Many conditions are necessary for growth and reproduction in animals
4. Changes take place during the growth of animals that can be measured in specific ways
5. There are individual differences in the physical development of animals.

Let us briefly take another example of how basic understandings are developed from "K" through 6th: *The Atmosphere*. At K-2 we might be concerned with the question of "What is Wind?". Some generalizations that could be developed from this question are:

1. Sometimes wind is warm: sometimes cold

2. Wind can carry light things—it makes clouds move
3. Wind pushes some things; it does not always help us
4. Weather changes result from winds.

At the level of grades 3-4 some questions which could be asked are: "What are some things we can do to show that air is real?", "What are some things we can do to show that air occupies space?", "How can we show that air presses on things?".

The generalizations we hope to develop from such problems involve simple experiments which children can do, including:

1. Air is all around us
2. Air cannot be seen
3. Air takes up space
4. Air pushes on things
5. Air pushes in all directions.

In grades 5 and 6 we continue our spiral approach and take up weather phenomena as an aspect of the atmosphere. From actual experiments developed through teacher-pupil planning we can lead to such generalizations as:

1. There is water in the air
2. Warm air holds more water than cold air
3. Wind comes from many directions
4. The speed of wind can be measured.

Thus we find that scientific principles can be developed from the kindergarten to the junior high school with little or no repetition of experiences. To do this the science sequence must be well planned and a healthy balance maintained in the various areas.

Methods of Science

Children learn science through doing things; by making collections; making observations; taking field trips; doing experiments; discussing what they have observed and done; and through reading. An effective science program is an *activity program.* When science becomes a mere reading program with little or no experiencing or experimenting with the materials of the environment, there is, for all practical purposes, no science program.

The emphasis in elementary science should be on giving children a broad background of science experiences. Many times, science experiences can be introduced by the very questions that children ask. However, the science program should not be confined to the incidental interests of the children but should be a planned program.

(Continued on page 132)

Developing a Periodic Table

By JAMES V. DeROSE

Head of Science Department, Chester, Pennsylvania High School

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA, sponsored by the National Cancer Institute, U. S. Public Health Service.

THIS paper has been planned to show, in a practical way, how a periodic table prepared by students can be used as a teaching device to point up the relationships among atomic number, electronic structure, and the chemical properties of the elements; also, to enhance students' understanding and appreciation of the logical arrangement of the elements with similar properties and configurations into vertical columns.

In past years without much basis in reason, our program included a correlated study of the periodic table and the halogen family. Several obstacles hampered our productive application of the periodic table. First, the use of the very short form (Mendeleeff's table) was inadequate for our needs. There seemed to be no real association, in the minds of our students, between this table and atomic number, electronic configurations, and recurring chemical properties. The vertical groups and the horizontal periods were present, but the students could not comprehend the natural development inherent in the elements. Second, some of the commercially available tables contain such a vast amount of information that the major points of emphasis were lost.

The long form, an improvement over other forms, still separates the lanthanide and actinide series from the table itself and places them at the bottom of the chart. These factors certainly prevent the students from recognizing and appreciating the practical value of the study of the periodic table. An analysis of the shortcomings of existing tables, aided by a study of the laminar chart,[1] inspired us to direct our students in an effort to prepare their own table. For our purposes, we shall refer to this pupil-prepared table as the long-long form [2] since it includes all of the elements. We have found this approach a mainstay in the teaching of chemistry.

To understand the procedures employed in this project, it is necessary to explain briefly the laboratory demonstrations and discussions carried on to develop students' awareness of two basic facts: (1) similarity of particles in all atoms; (2) difference in number of particles in atoms.

Our course begins with the usual introduction to chemistry: definitions, short history, tools, laboratory skills, and some technical terms. This is followed by a study of the atomic structure of the many elements.

Laboratory demonstrations are used to establish the electrical nature of matter. We begin with a spark taken from an electrophorus. The rubbing of two dissimilar materials is pointed out to the class and then the electrophorus is discharged against a student's nose. A rubber rod is rubbed with fur to give it a charge. The charged rubber rod is then used to charge two pith balls, which then repel each other. A glass rod is rubbed with silk and then used to charge two pith balls which also repel each other. Then it is demonstrated that one of each of the pairs of charged pith balls attract each other. Thus we prove that a pith ball charged with a rubber rod attracts a pith ball charged with a glass rod. Pith balls charged by the same rod, rubber or glass, repel each other. The conventional signs of negative and positive are assigned arbitrarily to the pith balls. The electroscope is used to identify the charge on a body. Polyethylene sheets and rods are rubbed with flannel, fur, or silk to show that a variety of materials can be used to develop charges. A polyethylene sheet rubbed with fur will raise the hair on a person's head. The electrostatic machine is then used to get larger sparks.

Next we introduce the subject of electrons and protons. Electrons can move and are subtracted from or added to a material, thereby achieving a positive or negative charge. The rubbing off of electrons from one material to another is emphasized to show that a variety of materials can be used. A condenser is charged with the electrostatic machine and discharged through the joined hands of all of the pupils. Care is taken not to charge the condenser too heavily. The pupils now have a "feel-

[1] A. N. Wrigley, W. C. Mast, and T. P. McCutcheon. "Laminar Chart of the Elements." *Journal of Chemical Education*, 26:216. 1949.

[2] Roland M. Whittaker. *Rudiments of Chemistry*. Ronald Press, New York. 1947.

ing" for similarity between electrons flowing througb the body and electric current.

The class is now ready to learn more about the properties of the electron. The electrostatic machine is charged and the charge is identified by the electroscope. The spark is then passed through the cathode ray tube. When the tube is connected properly to the knobs of the electrostatic machine, a beam of light is visible along the path taken by the electrons. If connected improperly, the electrons move in the opposite direction. Because of the construction of the tube, only a general fluorescence is visible at this time. This will prove that electrons pass in a definite direction from the negatively charged knob of the electrostatic machine to the positively charged knob. An induction coil is now used to give a definite, steady, and still larger spark or flow of electrons. This flow is passed through the cathode ray tube. A strong horseshoe magnet is used to deflect the beam. Thus it is shown that the electron flow is deflected by a magnetic field—attracted or repelled—depending on the manner in which the magnet is held. It is also demonstrated that a wire carrying DC current from a 1.5-volt battery is also attracted or repelled in a magnetic field. When the electrons move in the same direction, the wire responds in exactly the same manner as the beam of electrons in the cathode ray tube. Again the electrical nature of matter is stressed and the comparison fixed. A flow of electrons responds to the presence of a magnetic field. We show by using the vanes on a roller in an evacuated tube that this electron beam consists of particles having mass. The electrons striking the vanes move the roller back and forth as the direction of electron flow is changed. Thus the students learn that electrons are particles which have mass. Because of their kinetic energy, they are able to move other objects.

Protons and neutrons and their characteristics are now introduced to establish the three fundamental particles in the atom. At this point it is explained to students that the atom contains the nucleus which holds protons and neutrons; that the extra-nuclear portion of the atom contains the electrons distributed in definite energy levels or shells and that the atoms of matter differ only in the number of these particles. The term "atomic number" is used and the students taught to think of the 100 or more currently identified elements which differ from each other only in the number of particles contained. Since the atoms are neutral, they must contain the same number of electrons as protons. The following rule for the distribution of electrons in the various energy levels is introduced. The maximum number of electrons in any energy level can be obtained by using the formula $2N^2$, where N stands for the number of the energy level. This formula was modified by two restrictions:

1. Eighteen is the maximum number of electrons that can be found in the N-1 energy level.
2. Eight is the maximum number of electrons permitted in any exterior energy level, except the first, which may contain only two.

The students are taught to express the structure of an atom symbolically in the following form:

$$\text{Oxygen}\qquad {}_{8}O^{16}\qquad \begin{matrix}8p\\8n\end{matrix}\ \Bigg)\ 2e^{-}\ \Bigg)\ 6e^{-}$$

Now the students can diagram the structure of any element with reasonable accuracy. At this stage the periodic table is introduced. The filmstrip *The Periodic Table* [3] is shown to the class. This film reviews much of the structure of the atom and introduces the periodic table, the arrangement of the elements in a continuous strip, followed by a spiral arrangement which falls logically into a periodic arrangement. The pupils have already learned that the atoms of elements with similar electronic configurations have similar properties. The following brief assignment is given:

Prepare a continuous strip of paper 102 inches

[3] E. C. Weaver and L. S. Foster. Second Edition. Chemistry for Our Time Series: *The Periodic Table*. McGraw-Hill Book Company, New York. 1954.

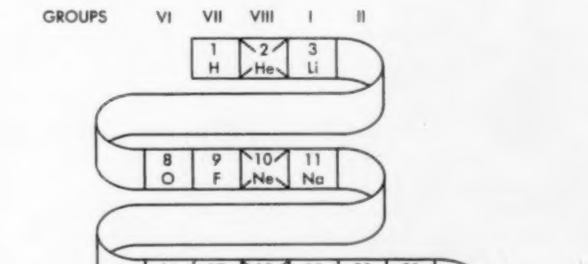

Plate I. Continuous Strip.

long and ¾ inches wide (suggested dimensions), marked off into one-inch wide sections. (See Plate I.) Every element from one to 102, in ascending order, is listed in the blocks. Each block should include the atomic number, the symbol, perhaps the name of the element, and its atomic weight. The atomic number is written above the symbol and the atomic weight below.

When the assignment was due, a variety of strips was presented. Some of the students had used adding machine tape with their blocks three inches long so that the total strips in some cases were more than 24 feet long. Most of them had, however, used more reasonable dimensions. Each strip was put to good use. The students were then asked to take their tapes and form a spiral. As they developed the spiral, they were instructed to keep the blocks containing the inert elements, beginning with

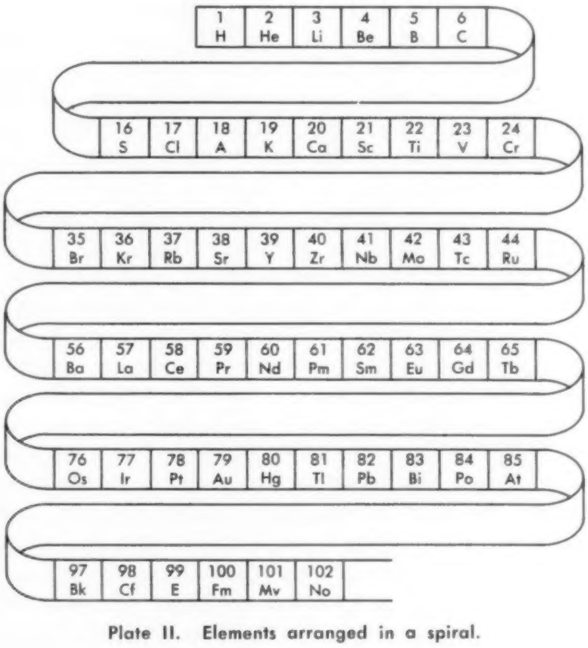

Plate II. Elements arranged in a spiral.

helium, directly below each other. (See Plate II.) This column of inert elements was taped together leaving a continuous circular table of the elements. The students knew that all of these inert elements had complete electronic configurations.

It is evident from the front view of the spiral that there are groups of elements arranged in vertical columns. It is called to the attention of the students that the elements within a vertical group have similar electronic configurations and chemical properties. They are then asked to cut the loop so

I	II																									III	IV	V	VI	VII	VIII
1 H																															2 He
3 Li	4 Be																									5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg																									13 Al	14 Si	15 P	16 S	17 Cl	18 A
19 K	20 Ca	21 Sc															22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y															40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 E	100 Fm	101 Mv	102 No																

Plate III. A Periodic Table of the Elements.

that every element is kept above an element with a similar exterior energy level. When this is spread out, the result is a periodic table which we have labeled the "long-long form." (See Plate III.)

The students have the opportunity to observe the relationships existing in the scheme of elements. By preparing their own periodic table, a keener appreciation and a deeper understanding of the value of the table develops. Pupils see further that certain elements are inert, and that these elements


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terminate different horizontal periods. They learn that chemical stability is associated with a complete filling of the exterior energy level of an atom. They can picture that atoms of the inert gases represent platforms of unusual stability. (This is demonstrated by one periodic table in a continuous strip which is kept stretched out along one wall of the laboratory with the inert elements colored red to indicate platforms of unusual stability.) They learn that all of the other elements are more or less unstable, depending on the degree of completeness of the exterior energy level, and that to secure the more stable atom configuration of the nearest inert element, a chemical change must occur. The students observe that similar electronic structure can be obtained in three ways:

a. Gain electrons to become like the next higher inert element.

b. Lose electrons to become like the preceding inert element.

c. Share electrons to achieve the electronic structure of inert elements.

The laminar chart [4] (as described) was used as the basis for a student project. A student prepared a 3′ x 4′ chart of plywood, in which each of the energy levels is portrayed by another layer of plywood. The laminar chart of elements by considering subshells goes beyond our usual consideration of a periodic table. I was amazed to find that the presentation made by the student who prepared the chart created enough interest to prompt the explanation of subshells. Many of the students were able to comprehend the ideas. The laminar chart portrays clearly and logically the electronic configurations of each of the elements and the relationship between chemical properties and the location of an element in the periodic table.

The rare earths, lanthanides, and actinides are included in this chart. These elements are becoming less rare and, consequently, will be studied more. The laminar chart, with each lamination representing an energy level, shows changes in energy level. This makes it possible to visualize the concept of depth for the various energy levels of an atom. I feel that the laminar chart has great value for high school use.

In any field of study, it is helpful for students to participate in the development and construction of a teaching device. The periodic table is a significant factor in the understanding of chemistry, because it gives order and direction to this body of knowledge and helps students avoid the meaningless acquisition of isolated, unrelated facts.

[4] Wrigley, op. cit.

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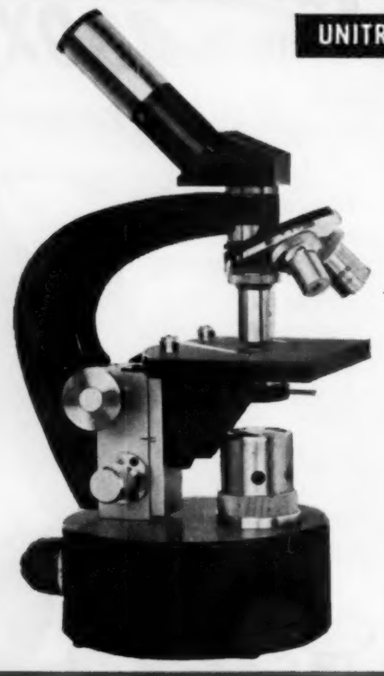

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Radioactive Isotopes

APPLICATION TO THE TEACHING OF HIGH SCHOOL SCIENCE

By GENE CRAVEN

Science Education Department, Oregon State College, Corvallis

and LILLIAN JONES

Sedro Woolley, Washington High School

THE greatest advance in the physical and natural sciences during the twentieth century has probably been in the fields of nuclear physics and chemistry and their application to the study of biological phenomena. The results of nuclear research have had a tremendous impact upon the thinking of mankind and will in all probability be a significant factor in determining the course of civilization.

Students are aware that they are living in an Atomic Age—an age of spectacular scientific achievement. The science teacher is obligated to capitalize on these interest arousers to direct the attention of his students to the basic aspects of nuclear research. One goal of the science teacher should be to develop in his students an understanding of: (1) the fundamental nature of nuclear energy and radioactivity; (2) the constructive as well as destructive potential of atomic energy; (3) the hazards involved in the use of radioactive materials.

Major constructive applications of radiation are: (1) use of the source itself as in radiotherapy; (2) tagging or labeling of compounds in various types of tracer studies; (3) dating based on decay of radioisotopes. Direct experimentation with radioisotopes often requires the use of dangerously large quantities while radioactive dating is too elaborate for use on the high school level.

The purpose of this article is to consider briefly a typical radioactive tracer experiment, how to design and conduct such an experiment, and to suggest demonstrations that can be done by the high school science teacher or experiments that students can do under strict supervision. The suggested radioautography "pie-pan technique" involving a minimum of equipment and expense is well within the budget of most high school science departments and the capabilities of any good laboratory worker, yet offer basic understanding of modern techniques used in biological research. It should be emphasized that this type of experimentation is made possible by relaxation of some former restrictions by the Atomic Energy Commission concerning radioisotopes.

Experiment Design

Poor techniques and experiment design are undesirable in any laboratory and cannot be tolerated when radioisotopes are being used. Radioactive tracer experiments should be designed in such a manner that the concentration of the radioisotope in the end product will be sufficient to be conveniently detected. The practice of adding "some" radioactive material to a system in an experiment should be avoided; it is an undesirable technique. It may result in waste of the radioisotope, it can be hazardous to the experimenter or it may be too little to be of any value in the experiment. Although tracer experiments are qualitative in nature, they should be made as quantitative as possible in regard to the portion of the biological system engaged in metabolism, the desired concentration of the radioisotope in the product, and the quantity of "hot" material introduced into the system. An example of a general type of radioactive tracer experiment is given below.

The purpose of this experiment is to show the role played by light and chlorophyll in the photosynthetic fixation of $C^{14}O_2$ by plants. This experiment has been satisfactorily conducted using the $C^{14}O_2$ generator (Figure 1), a device which is relatively inexpensive and safe to use when properly assembled and operated with care.

I. Suggested investigations which may be conducted in the generator using a single charge of $C^{14}O_2$.

A. Effect of light.

(1) Using identical leaves, encase one in light-tight wrapping of aluminum foil; leave one unwrapped.

(2) Leaves may be wrapped in colored Cellophane to determine the effect of colored light.

B. Effect of chlorophyll.

(1) Use leaves containing varying concentrations of chlorophyll (dark green bean leaf and light green leaf from head of cabbage).

(2) Place a drop of strong acid on a leaf to kill the chlorophyll in a small area.

(3) Use a colored flower.

(4) Use growing plant leaves which are some color other than green.

II. Activity desired:

In studying results obtained in a tracer experiment of the foregoing type, radioautograms may be made of the object itself (the leaf) or of a paper chromatogram made from an extract of the object. For radioautographic examination,[2] the minimum apparent counting rate (Geiger counter count) desired in making a radioautogram can be considered approximately 100 counts per minute (cpm) per 10 micrograms of solid plant material (10 μg of material usually gives an optional size spot) confined to an area of 1 cm^2 or less on the chromatogram. Since Geiger counter efficiency for C^{14} particles is approximately 5%, this desired activity is 2000 disintegrations per minute (dpm) per 10 μg of solid plant material. It has been established that a total of 10^7 disintegrations per cm^2 will produce a readable radioautogram. The correct exposure time in this case would be:

$$\frac{10^7 \text{ disintegrations}}{2 \times 10^3 \text{ dpm}} =$$

5000 minutes or approximately 3½ days. In making a radioautogram of the leaf, it is desirable that the specific activity of carbonaceous matter be at least 200 dpm per cm^2 per μg.

III. Consideration of the Biological System:

Assumption (A): 90% of the plant material is water; therefore 10% or 1×10^5 μg of leaf solid is present in each gram of green leaf. Assuming uniform labeling, the total activity required for one gram of leaf $= 1 \times 10^5$ μg leaf solid $\times$ 200 dpm per $\mu g = 2 \times 10^7$ dpm per gram of green leaf used.

[2] Determination of relative specific activity and distribution of radioisotopic labeled compounds by examination of film exposed by radioactivity emitted from the object being studied.

Assumption (B): Although it is possible to incorporate all $C^{14}O_2$ in the system into plant material, it is safe to assume 50% of the $C^{14}O_2$ will actually be incorporated into plant material by photosynthesis; therefore 4×10^7 dpm per gram of leaf will be needed. This will require $\frac{4 \times 10^7 \text{ dpm/g}}{2.2 \times 10^6 \text{ dpm}/\mu c} = 18.2\ \mu g$ of $BaCO_3$ of reasonably high specific activity for each gram of green leaf used. $BaCO_3$ from Oak Ridge National Laboratory or other commercial sources generally contains 10 to 30% C^{14} and is adequate for experiments of this type.

IV. Introduction of the Radioisotope: *CAUTION—Work in hood or outdoors.*

A $C^{14}O_2$ generator (Figure 1) can be successfully used to synthesize C^{14} labeled compounds in plant leaves by photosynthesis. $C^{14}O_2$ is produced by injecting 1N HC1 through the serum bottle cap onto the $BaC^{14}O_3$ in chamber "A" of the generator, using a hypodermic needle.

V. Description of the Experiment:

Leaves are left in the $C^{14}O_2$ atmosphere in the presence of light for a predetermined length of time. 0.1 N NaOH solution is then injected into chamber "B" (Figure 1) and shaken intermittently for one hour to absorb excess $C^{14}O_2$ (which may be recovered). If an extract of C^{14} labeled compounds is desired, the leaves upon removal from the generator may be killed by dropping them into hot 80% ethanol solution.[3] If a radioautogram of the leaf is desired, place it in an oven at 70° C for 15 to 20 minutes to inactivate the leaf and thus prevent C^{14} loss through respiration.

Detection of Radioactivity

Two common methods for detecting radioactivity are radioautography and the use of radioactivity counters. Due to the limitation by AEC license of the quantity of a radioisotope that can be purchased, tracer experiments must be designed using relatively small amount of activity; therefore, the detection device must be sensitive enough to detect very small amounts of radiation. Geiger counters equipped with thin mica windows (less than 2 mg/cm²) can be satisfactorily used although their efficiency is low for low energy beta particles emitted by C^{14}.

The radioautograph is strongly recommended for detection of radiation in biological systems since low activity may be detected and the relative activity of various areas of the specimen are shown on the radioautogram. This film technique is simple enough that anyone can use it and the cost of detection may be kept to a minimum. When using this technique, the radioactive specimen is dried and placed next to the film emulsion.

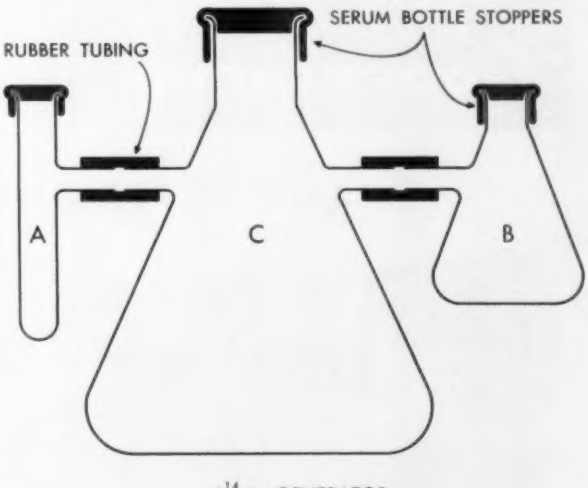

Figure 1

The film and specimen are wrapped with black paper and aluminum foil to prevent exposure by light, then set aside for radioactive exposure. No-screen X-ray film must be used for C^{14} radioautograms but ordinary film may be used with isotopes emitting high energy beta particles. Outdated X-ray film (provided it is not too old) which may be obtained from a local doctor or hospital is satisfactory for this work. Correct exposure time is estimated according to procedure in Part II above but may be determined by trial and error; however if a Geiger counter is available, the time may be more accurately estimated. A desirable image is produced by an exposure of 10^7 disintegrations per square centimeter for this purpose.

Paper Chromatography

Paper chromatography is usually used in tracer work to separate various compounds present in a biological system. The "pie-pan technique,"

(Continued on page 131)

[3] If the generator contains only one plant species and no radioautogram of the leaf is desired, the hot ethanol solution should be added prior to addition of the NaOH solution.

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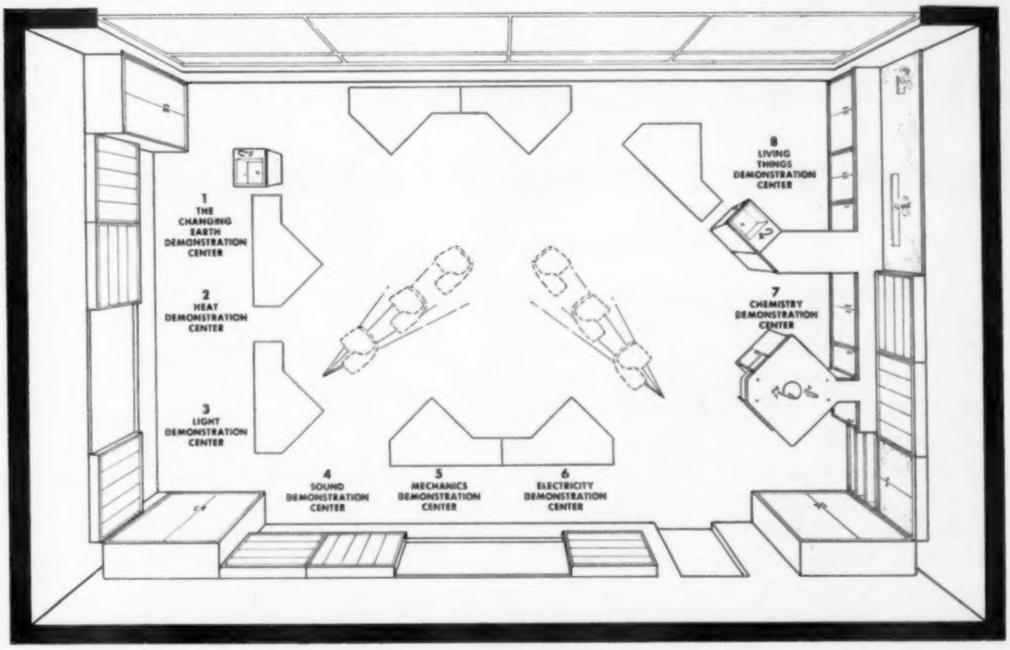

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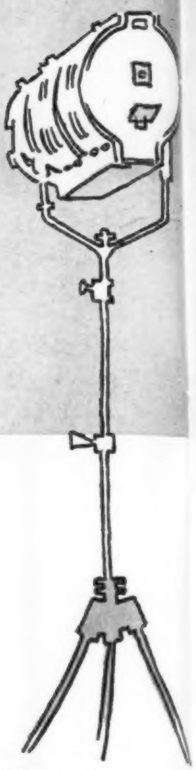

Science Teaching Objectives and Methods

By J. DARRELL BARNARD

Chairman, Department of Science and Mathematics Education, New York University

In light of many of the criticisms that have been directed toward science teaching, the question of which science should be taught is a timely one. Traditionally, science has been viewed as factual. From the point of view of content, science is built upon facts. But to teach facts, in and of themselves, is not to teach science. The evidence from research clearly indicates that to teach science in this way is a waste of time and effort. It has been found that up to 70 per cent of the specific facts learned in a science course are forgotten within one year after the completion of the course. In light of this evidence one research worker has pointed out that, since most final grades in science courses are assigned on the basis of scores made on factual examinations, the A's go to the student who forgets the most.

On the other hand when science is taught to help students understand principles and generalizations, the retention curve does not drop. Some studies indicate that it may even rise slightly above its position at the completion of the course.

We should cite this evidence to the uninformed who would admonish us to "discipline the minds" of young people by making our general science, biology, chemistry, and physics tough memory courses. We should keep this evidence in mind when we are tempted to enrich our science courses by merely making longer assignments in the textbooks. The validity of the tests to measure achievement in science should be judged in light of this evidence.

To develop critical thinking is generally supported as an objective of science teaching. Numerous studies have been conducted in an effort to define the specific behaviors involved in critical thinking as it relates to problem-solving in science. Other studies have dealt with the extent to which science teachers teach for these behaviors. One study in 1932 revealed that some science teachers believed that the study of science concomitantly resulted in the development of behaviors related to critical thinking. Others felt that a lesson now and then would accomplish the objective. A later study in 1950 indicated that the attitude of science teachers, as revealed by the way they taught, had not changed much during the 18 years.

The research indicates that critical thinking can be taught. Those, however, who would teach for it must understand the behaviors involved in critical thinking. Furthermore, they must make it possible for students to practice these behaviors in their science classes. For example, one who is thinking critically asks questions, he speculates about answers, he plans and evaluates ways of finding out, he questions the validity and reliability of evidence, and so on. The teacher must, therefore, provide situations where students are motivated to ask questions, to speculate about answers, to plan ways of getting evidence, and to evaluate it. Dr. Ellsworth S. Obourn, secondary-school science specialist in the United States Office of Education, has prepared a comprehen-

sive check list which teachers can use to determine how well they are making provisions for learnings such as these.

A question which frequently faces the conscientious science teacher is: "Am I using the most effective methods?" Findings from research provide some clues to the answer. There have been a number of studies which have yielded evidence regarding the relative effectiveness of two or more methods of teaching science. In these studies, when the criterion for comparing the two methods was gain in factual knowledge, the method which put the greater emphasis on this type of learning was usually found to be superior. If the criterion was understanding generalizations, the favored method was generally the one which provided more experiences in this type of learning. And so it goes with the other objectives. The evidence from research shows that the science teacher achieves the objectives for which he teaches. With the possible exception of rote learning of facts, the superior method is usually the one by which the students are brought into more active participation in their learning experiences.

If the objectives are viewed as verbal competencies with the vocabulary, generalizations, methods, and attitudes of science so that definitions can be recited in class or correctly checked as true or false on an objective examination, a method characterized by much talk and drill would seem to be most appropriate.

There is a distinction, however, between verbalism and understanding in science. Students may do very well on vocabulary tests and fail miserably on tests designed to measure understanding of generalizations and their ability to think critically in solving problems.

When, on the other hand, the objectives are viewed as behavior competencies quite different methods must be employed by the teacher. If a science teacher believes that his students should grow in their ability to solve problems, the evidence indicates that he must design his course so that they will have guided, conscious experiences in solving problems. If a science teacher believes that his students should grow in their use of scientific attitudes, they must have many experiences with choices of action where the attitudes are involved. If a science teacher believes that his students should grow in their understanding of selected generalizations of science and their ability to apply them, they must become actively involved in experiences out of which they "catch" the idea of the generalization.

Among the various methods, which by controlled experiment have been found to be effective, no one can be proclaimed as unquestionably superior to others. Because of differences among teachers, elements of one or several so-called methods may be highly effective when handled by one teacher but of questionable value in the hands of another. Differences in the ability levels of students must be taken into account in deciding what techniques will be used.

There is no *one* method of teaching science. Nor is there a method that will be equally effective for any one teacher in all teaching situations. The beginning teacher, who assumes that during his first few years of teaching science he will develop an organization and a method that will serve him well for the remainder of his professional career, is doomed to disappointment. Science is dynamic. Students change from class to class and from year to year. The science teacher himself is undergoing change. It is inevitable that his techniques of working with young people must frequently be evaluated and modified in ways to make his teaching more effective.

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Ninth Grade Science Research

By ANNE E. NESBIT

South Junior High School, Pittsfield, Massachusetts

This report was an entry in the 1957-58 STAR (Science Teacher Achievement Recognition) awards program conducted by NSTA, and sponsored by the National Cancer Institute, U. S. Public Health Service.

CURIOSITY! Imagination!! Patience!!! Taken individually these nouns may be essential tools for success in a variety of occupations. Taken together they are not necessarily restricted to scientists, but they certainly are recognized as being absolute necessities in his "tool chest" if he is going to meet with success, be he a future science teacher, researcher, or technician. Though all this is realized by today's science teachers, the big questions confronting us are:

1. How can we supply these "tools" to our students if they don't already possess them?
2. How can we sharpen these "tools" for those who already give evidence of having them?

My story begins in September, 1953 with the opening of our new junior high school in which science was being offered to students as a major subject for the first time in the history of our city. In addition to science, the school program called for a science club as an extra curricular activity. As chairman of the science department, I was elected to direct the activities of these future "scientists(?)." Students interested(?) in science were invited to join. This invitation was my first big mistake! I quickly observed that most of my members were people looking for spectacular entertainment. Try as I might to interest them in an over-all problem, I continually met with failure. There were however in this group, three students curious and imaginative enough to proceed with research of their own.

My work with these three very interested students made it obvious that a 40-minute club period, twice a week, was not sufficient time to gather necessary materials, experiment, clean-up and, at the same time, get anything of value accomplished. Thus the principal agreed to give the class two extra periods—these supplanting those formerly used as a two-period elective (as typewriting or shop).

The following admission standards were devised:

1. The student must, as an eighth grader, show both an interest and aptitude for science.
2. The student must have demonstrated his ability to cooperate and get along with other people.
3. The student must be willing to put into his project whatever extra time may be necessary. (This requirement was important to us for it meant release from the obligation of seeing that a pupil was on this or that bus.)

The next step was to set a limit of 15 students to the class.

Growth of Idea

The first two or three periods in September, 1954, were devoted to orientation. The nature and purpose of the class were reexplained.

Some students already had an idea for a project; however, most had yet to decide on one. Individual pupil-teacher consultations were held and, with the help of project ideas from NSTA and various science books, a project was decided upon by each student. Individual "research" was

Experimentation begins.

VERA V. FIELDING PHOTO

begun. And here is where my next mistake was made! I never should have let these boys and girls begin to "swim" in such deep "water." Fifteen voices were asking me fifteen different questions all at once. My head was in a whirl and I resolved never to let this happen again. As time went on, I discovered that many questions were peculiar to the entire class, as how to light the Bunsen burner. I also discovered that, at the most, I could only help about six pupils during the period. As a result, the other nine questioning minds patiently waited until the following lesson hoping I would get to them.

By the close of the year, my results with this first class were as follows:

A. Nine students became really interested in some phase of science and, considering their slow start, had accomplished something of value.

B. Three students had shown some progress but their interest in science, at this point, was definitely questionable.

C. Three students had accomplished nothing and admitted that they were not as interested in science as they thought they were.

Note: I like to feel that this realization was of value to them in selecting their high school program.

The most important outcome of the entire year was the realization that my idea was a good one and that, with changes, it could be made to work.

September, 1955

The science research class was now twenty-four in number. The increased enrollment resulted from extreme demand for the class from students and parents alike. Another teacher in my department assisted me with the group and we each took twelve students. The following changes were made from the previous year:

1. Closer supervision of project choice. Each student was required to write out his plan of action, why he had chosen the project, and what he hoped to accomplish with the project.

Result: Much less shifting of project interest, but still too much to satisfy me.

2. Students working in identical or related fields were instructed, as a group, on the various lab techniques which might be required.

Result: Lessened demand on teacher for attention and hastened project work.

VERA V. FIELDING PHOTO

Collecting the data.

3. A requirement was set for each student to keep a class log of his work for each period. If nothing was accomplished, he was to write for that date, "nothing done!"

Result: There was much less wasted time.

4. Periodic Seminars. Each student stood before the group to tell the nature of his experiment and what he had accomplished to date.

Result: a. Stimulated students to accomplish something in order to avoid embarrassment.

b. Other students were able to suggest how the speaker might improve his work or solve his current problem.

c. Thirty speakers took 12 periods of time or three weeks away from project work. This was not good!

5. Special Science Research Report Card: Each student was evaluated on various science qualities.

Result: Spurred better work but report was so complete that parents questioned why such a report could not be given in every subject. As this was impossible, I had to abandon this idea the following year.

6. Library Improvement. A special science research library was organized. The school purchased many valuable books for me, and the science teachers in the school contributed their own personal books. This library is located in a glass cupboard in my classroom and is locked, at all times, except when in use.

Result: Science prestige for the students but—more important—valuable aids for the teacher.

7. Science Fair. Each student was required to submit his project, regardless of its condition, for the Fair. The science research group formed a special section of its own and these students competed among themselves. This was done in order not to discourage other school students.

Result: There was good, sound competition between each other. Excellent projects were completed, many of which had carried the student into college science. The nature of many of the projects was so complex that the school officials and general public were amazed that so much could be done by a ninth grader.

8. Newspaper Publicity. A feature writer for our local paper visited our class, took pictures of their projects and wrote a very interesting column describing what she saw. This, incidentally, was done just before the Fair.

Result: This awakened Pittsfield to what we were trying to do, and it also served as an excellent advertisement for our Fair. The class not only gained marvelous publicity for itself, but it also won the admiration of many industries in and around Pittsfield.

In spite of all the progress we had made this year, there was much yet to be done. I still was not satisfied with the speed with which research moved forward. I also felt that much valuable time was still being lost in really "getting underway." I decided I must strengthen these weaknesses the following year.

September, 1956

The year opened in our school with the formation of three honor classes—one each in English, algebra, and science. I was assigned to teach the science honor class. Thus, I decided to make this class also my science research class. In an effort to improve orientation, the following practices were developed:

1. The showing of current films:

Result: Students were quick to see that science research truly calls for curiosity, imagination, and patience! In addition, they saw the importance of being accurate and of being tidy. They also saw how some first-rate scientists solve their problems.

2. Following the films, twelve periods were devoted to instructing the *entire* class, as a unit, on lab safety, general lab techniques, lab cleanliness, and good housekeeping.

Result: There was now no time lost in showing individual students how to light the burner, dilute acid, make up solutions, clean glassware, and other tasks.

3. A set of twenty-seven elementary, short-range, science problems were next submitted to each student. The problems were evenly divided among the fields of biology, chemistry, and physics. The student was permitted to select any *one* problem for solution. Upon its successful completion, he was required to select still another problem but this one had to be in a field different from his first choice. Having completed this, he was able to begin his long-range project.

Result: a. The student learned the importance of a well controlled experiment.

b. He acquired skill in designing and successfully carrying out an experiment.

c. He learned how to properly gauge his time.

d. He became acquainted with all the tools of the laboratory—textbooks not excluded.

e. These small experiments gave me an opportunity to raise thought-provoking questions relative to each experiment. This proved to be a wonderful way to arouse interest in a long-range problem.

f. Many students who thought they were definitely interested in one field of science, suddenly became interested in the field of their second problem. In this way I gained many researchers for physical science which I would otherwise have lost to biological science. Not only that, but once having started their long-range problem, not one student wished to change his project. This was, indeed, an accomplishment.

I also continued with the daily report logs inasmuch as they had proven so successful the previous year.

We again had our Fair and once again the science research section brought superlative praise from all who visited it.

September, 1957

With the problems of proper orientation and stimulation solved, the next problem to consider was whether or not to drop from the course anyone who showed, from the start, the inability to design and plan out an experiment. These students will never make research scientists, but they may make good technicians. For this reason, I question the wisdom of asking them to leave. My answer to this problem will not come until I have a chance to observe the future paths of the students of my first two classes. (These are now high school seniors and juniors respectively.)

General Summary

Science research can begin on a ninth-grade level. Success can be obtained by:

1. Proper scheduling. A double period is a necessity.
2. Proper selection of students. We have found our admission standards very satisfactory.
3. Proper orientation
   a. Films. Use current subjects and vary the films.
   b. Training for entire class in basic laboratory fundamentals.
   c. Successful completion of two elementary short-range science problems.
4. Proper stimulation
   a. Daily logs.
   b. Seminars.
   c. A science fair entry.
5. A generous supply of resource information
   a. Textbooks, both high school and college.
   b. Laboratory manuals, both high school and college.
   c. Pamphlets offered for the asking from various industries and science professions.
   d. Project ideas and samples of successful projects. These may be obtained from the National Science Teachers Association.

Evaluation

Though not enough time has elapsed to permit an accurate evaluation of the class, I can cite the following as indicators of success:

1. Former students keep returning after school to learn what their successors are doing.
2. Former students have organized a high school science club in order to further the projects begun in our school.
3. There are constant inquiries from seventh and eighth graders and their parents as to admission requirements to the class.
4. With one exception, no student in the last three years, who has started the class, has ended as a failure as far as science research is concerned.

In conclusion, let me say that I believe I have found a way to develop the curiosity, imagination, and patience of potential, future scientists. I have found that, in the majority of cases, these qualities are nurtured but can, on occasion, be planted in students.

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Is This Trip Necessary?

By HAROLD E. TANNENBAUM

Science Education, State University Teachers College, New Paltz, New York

EDITOR'S NOTE: The third in a series of articles prepared by Dr. Tannenbaum is continued herewith in cooperation with NSTA's Business-Industry Section.

RECENTLY, one of my colleagues kept mumbling and grumbling about the useless effort that was being expended on his part. He was taking his class to visit a large plant about fifty miles away. Oh, the problems! Buses to be arranged. Teachers to be pacified. What did he mean by arranging a trip on the very day when there was to be an English quiz? How many times did he think students could miss a French class? After all, these same students were excused just two weeks ago to go to the junior class meeting. And here was my colleague asking that they be excused again just to visit an electronics factory. Then there were all the details about costs. What was to be done about six students who could not raise the necessary dollar and seventy cents? How about the students who might be absent the day of the trip? Should they pay part of the expenses or should their fares be refunded? "If you ever catch me arranging another field trip, please have my head examined," was his parting comment.

Two days later I saw him again. With a certain amount of fear in my heart, I asked: "Well, how did the trip go?" What an outpouring! It was the most wonderful thing that could have happened. It was worth all the effort and all the discussions and consultations with the English department and the French instructor, and the bus company, and the school office. Why? Because the trip was a huge success since the students really had seen the principles which they had been studying in class applied and used in a practical and concrete situation. What makes a good field trip? When should a field trip be used? How can one be arranged? In short, when is the field trip game worth the candle?

There are three purposes which can be served by taking a field trip:

1. A field trip can be used to develop new interests and extend the range of interests which already have been aroused.
2. A field trip can organize and verify previously learned materials.
3. A field trip can give young people a chance to meet with men of science and industry and thus glean vocational information.

Any one of these objectives is sufficient reason for taking a trip. If more than one can be served by a trip—and often this is the case—then the trip is more than worth the effort. But, and it is a big "but," these objectives will not be met without planning and organization. It takes a heap of work to make a field trip worthwhile. And the burden of the work falls on the teacher.

The first task for the teacher is to know his community. Such knowledge can be best organized through a community resource file. Of course, the file should have all of the routine kinds of information that teachers need—the name of the plant or installation; the name of the

At Du Pont's Haskell Laboratory for Toxicology and Industrial Medicine, Regina Heher, Laboratory toxicologist provides a look at first-hand research to students (l. to r.) Anne Milbouer, P. S. du Pont HS; Donald Cameron, Springer School; Donald Spangler, Dover HS; and Rugh E. Walls, Harrington HS.

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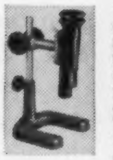

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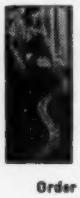

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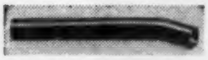

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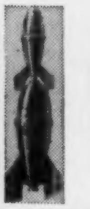

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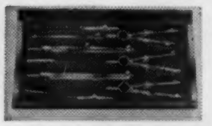

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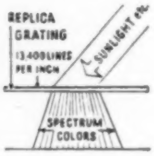

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person who can help arrange the trip; the times when such trips are possible; the number and ages of students who may make visits; the length of time that such a trip takes; other pertinent information such as directions for getting to the plant, lunch facilities, and others. But this kind of information is only part of what is needed.

Assembling Materials

The file should contain two additional kinds of materials. First, the various aspects of the plant operation should be listed in the file along with the science principles which are illustrated by each phase of operation. Seeing the pasteurizer at the milk-processing plant and having it explained can truly clarify the ways in which men have controlled the undesirable effects of bacteria on milk. For elementary school children this can be quite valuable. In like manner, high school physics students who visit a coal breaker of the specific gravity type can gain a first hand understanding of specific gravity that will take the concept out of the vague and nebulous and bring it into the real and concrete. Second, it is also advantageous to list the kinds of information which can be gathered from men in the plants.

Once it is determined that a field trip is desirable—it should meet at least one of the three criteria which have been outlined and it should be the best way to meet it, too—then the planning begins. Plans need to be made with the students, with the administration of the school, and with the agency to be visited. First must come the administrative details: Does the time satisfy all the people concerned? Will the desired materials be on view when the students come to visit? Are the details concerning buses, meals, rest stops, and parent approval arranged?

Then, the educational planning steps can be taken. The guide who is to show the group around, must know the specific purpose of the trip. He should know how the field trip fits into the over-all objectives towards which the group is striving. Unless he is aware of these long-range plans, he will not be able to determine which aspects of his plant are of immediate concern to the children. As the teacher goes around the plant beforehand with the guide, they together can pick out those parts which seem most important and appropriate. Then they can plan how they will explain these things to the students in simple and clear language. Just as the experts who come into the classroom need

IBM PHOTO LABORATORY

Students from Haldane Central School, Cold Spring, N. Y. visit IBM Poughkeepsie Plant. John Meehan explains electronic computer operation.

help in order to convey their information to the young people, so these guides need help. They should know what technical language they may use and what they may not use. In planning this session, the guide can be briefed on the kinds of questions that the youngsters probably will ask and they can be given help in finding ways in which these questions may be answered with accurate but non-technical language.

Incidentally, these planning sessions often offer good opportunities for special activities for some of the more able students. Such students can accompany the teacher on the preliminary visit to help make the plans. Furthermore, some plants cannot accommodate a class-sized group. In such cases, student committees can be used to visit these plants and report their observations and findings to the entire class.

Planning the trip with the students is the next step in the process. After all, the men who spend their time taking students through a plant deserve to have these young people thoroughly prepared for what they are going to see and hear. The students must know the educational purposes of the trip: why the trip is being taken, and what they can expect to learn. And they must understand the relationships between the trip and the unit of study which they are carrying on in the classroom. They should know the specific problems which the trip will answer.

The students should also receive in advance their assignments for the work to be accomplished through the trip. These assignments will vary from trip to trip, but there are a number of

(Continued on page 140)

Classroom Ideas

Biology

Starch Digestion Demonstration

By EDWARD FRANKEL
Bronx High School of Science, New York City

One of the most popular demonstrations in general science and biology is the salivary digestion of starch. Some years ago, the author improvised a simple demonstration which enabled the entire class to actually see starch digestion take place within less than one minute. It has been both effective and provocative in focusing attention on digestion as a process in which insoluble materials are made soluble.

The demonstration consists of two large test tubes filled with 0.5 per cent boiled starch suspension; that is, the print is just barely visible when the tube is held in front of a newspaper. Saliva is added to one tube and an equal quantity of water to the other. Both tubes are stoppered and mixed by inverting a few times. Within thirty seconds, the starch suspension containing the saliva becomes transparent, clear enough to be able to read newsprint through it; the other tube remains cloudy. At this point both tubes are usually tested for sugar and starch. The starch-saliva mixture is found to contain a reducing sugar but no starch; the control tube contains starch but no sugar.

Recently, the author devised a demonstration in which it was possible for a class to see the starch disappear as it is being digested by saliva. Using the same starch suspensions as above, a few drops of Lugol's are added to each tube until a blue color results. To one tube add saliva and to the other tube an equal quantity of water. Stopper and mix by inverting. Within one minute the blue color in the starch-saliva mixture begins to fade and disappears; the control tube retains its original deep blue color.

In testing for the products of salivary digestion, Benedict's or Fehling's solutions are largely used. With these reagents, it is not possible to distinguish between maltose and glucose since both are reducing sugars. Should it be necessary or desirable to demonstrate the fact that glucose is not the end product of salivary digestion of starch, it can be done with preparations containing the enzyme glucose oxidase which converts only glucose to gluconic acid and hydrogen peroxide. The hydrogen peroxide reacts with a chromogenic acceptor, thus producing a color. The enzyme preparation is available commercially as "Tes-Tape" and "Clinistix" used to test for glucose in urine. It is also sold as "Glucostat," a reagent intended primarily for blood serum or plasma glucose. With any of these reagents, the end products of salivary digestion give negative results since glucose is not formed. What are the end products of malt diastase digestion of starch?

Chemistry

Diagramming Ionic and Covalent Compounds

By SAMUEL C. DICKIESON
Mynderse Academy, Seneca Falls, N. Y.

It has always been a difficult acrobatic act of chalk, chalkboard, and eraser to teach electron transfer in ionic (electrovalent) compound formation. It is equally confusing with chalk to show the "sharing" of the covalent bond. Students have always been confused as to where the "shared" electrons have come from, and the required chalkboard gymnastics leave the teacher in a cloud of dust and the student confused.

I would like to suggest the use of the bulletin board and two cards of two different colored thumb tacks. If the bulletin board is not conveniently located for use in teaching at the front of the room, I would suggest a sturdy piece of *celotex* or *homosote,* both excellent substitutes. Using "nuclei" cut out of heavy paper and marked

NSTA CALENDAR

As a regular feature of *The Science Teacher*, the calendar will list meetings or events of interest to science teachers which are national or regional in scope. Send your dates to *TST's* calendar editor. Space limits listings of state and local meetings.

April 3-4, 1959: CESI, St. Louis, Missouri

March 31-April 3, 1959: Annual Convention, National Catholic Educational Association, Atlantic City, New Jersey

March 31-April 4, 1959: NSTA Seventh National Convention, Atlantic City, New Jersey

June 28-July 3, 1959: NEA Representative Assembly, St. Louis, Missouri

July 1-3, 1959: NSTA Annual Summer Meeting and business meeting of Board of Directors, St. Louis, Missouri

with the proper number of protons and neutrons, arrange an atom such as sodium, potassium, calcium, or magnesium with its properly arranged electrons (thumb tacks of one color); and next to this the typical non-metallic atom of chlorine, oxygen, fluorine, or sulfur with its properly placed electrons (thumb tacks of the other color). Electrons are easily "transferred" to form the ionic state and reach the "ideal" electron configuration of the inert gases with little effort, and moved back again for the inevitable question: "Would you do it again, please?" The same use is made in covalence, showing the diatomic molecule, or the typical covalent compound. Use low atomic numbers in order to save "thumb tack confusion." In the latter case, having the two colored sets of electrons, it is quite clear that there is a sharing, and that you have not introduced any "foreign" electrons into the sharing. It is easy to count the electrons for each atom, showing no deficiency nor addition.

This same technique is also useful in showing the ammonium ion; the polar property of water and hydrogen chloride; and the non-polar property of carbon tetrachloride and methane.

Convention Features

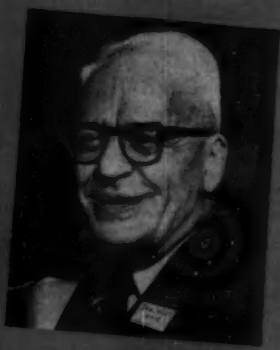
ATLANTIC CITY • MARCH 31-APRIL 4, 1959

KATHERINE E. HILL. Associate Professor of Education, New York University, New York City. Presiding Thursday afternoon, Session A. Subject: "Curriculum Redesign in Elementary Science."

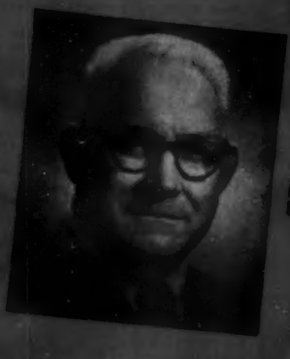
MAYNARD M. BORING. Consultant to the Federal Government on Engineering and Scientific Manpower, Washington, D. C., and Director of Council for Basic Education. Speaker, Business-Industry-Education luncheon, Thursday. Subject: "Education—Its Immediate Opportunities and Pitfalls."

ALEXANDER G. KOROL. Member Research Staff, Center for International Studies, Massachusetts Institute of Technology, Cambridge. Speaker, Second General Session, Wednesday evening. Subject: "Science Education in the Soviet Union."

CHAUNCEY D. LEAKE. President-Elect, American Association for the Advancement of Science; Assistant Dean, College of Medicine, The Ohio State University, Columbus. Speaker, Annual Banquet, Thursday evening. Address: "In the Palms of Your Hands."

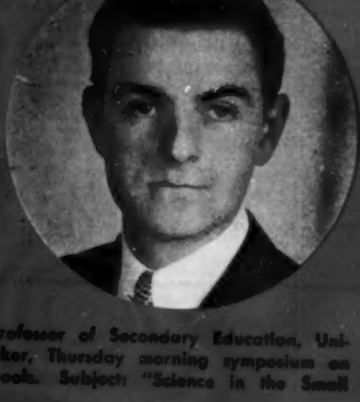


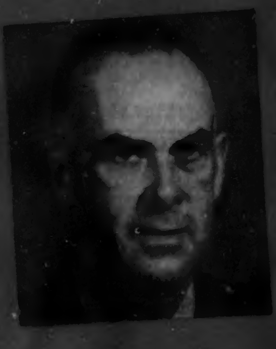
GORDON N. MACKENZIE. Head, Department of Curriculum and Teaching, Teachers College, Columbia University, New York City. Address at supervisors' luncheon, Tuesday. Title: "Problems of Supervision in Today's Schools."



ELLSWORTH S. OBOURN. Specialist for Secondary Science, U. S. Office of Education, Washington, D. C. Speaker, Second General Session, Wednesday evening. Subject: "Science Teaching in the Schools of Europe and Southeast Asia."

J. STANLEY MARSHALL. Professor of Science Education, Florida State University, Tallahassee. Panel speaker, Friday afternoon. Topic: "The Status of the Major Areas in Elementary Science—The Physical Sciences."





COLONEL THURSTON T. PAUL, JR. Deputy Commander, U. S. Army Ballistic Missile Agency, Redstone Arsenal, Alabama. Featured speaker, Fourth General Session, Friday evening. Topic: "The Challenge of '76."

JAMES A. RUTLEDGE. Associate Professor of Secondary Education, University of Nebraska, Lincoln. Speaker, Thursday morning symposium on Science Education in American Schools. Subject: "Science in the Small Schools."

DONALD W. STOTLER. Supervisor of Science, Oregon Public Schools, Portland. Symposium speaker, Third General Session, Thursday morning. Subject: "Large Cities, American Youth, and Science Education."

ELSTON SEAL. Student (left), North Plainfield High School, New Jersey, with 1958 Regional Science Fair project. Participant, Student Demonstrations, Thursday afternoon. Subject: "Thermistors: Electric Thermometers."

FLETCHER G. WATSON. Professor of Education, Harvard Graduate School of Education, Cambridge, Massachusetts. Presiding officer and speaker, Fifth General Session, Saturday morning. Subject: "Governmental, Industrial, and Collegiate Activities."

ROBERT T. LAGEMANN. Head, Department of Physics and Astronomy, Vanderbilt University, Nashville, Tennessee. Parallel Sessions for High School and College Teachers, Group B: "Content Selection for Science Programs Enrolling Academically Superior Students"; Friday morning.

HAROLD E. TANNENBAUM. Professor of Science Education, New York State University Teachers College, New Paltz. Director of Elementary Science Workshops, Thursday and Friday mornings and Saturday afternoon.

GEORGE H. SHAY. Staff Manager, Government Sales, Johns-Manville Corporation, New York City. Featured speaker, New Jersey Science Teachers Association luncheon, Saturday. Subject: "The Challenge—New Jersey Industry's Responsibilities!"

MILTON O. PELLA. Professor of Science Education, University of Wisconsin, Madison. Chairman of Discussion 1A: "Helping Elementary Teachers Who Lack Training in Science." Thursday morning.

KAREN L. FRANK. Sophomore, Irvington High School, New Jersey, displays winning exhibit in biology at Greater Newark Science Fair. One of ten participants in Student Demonstrations feature, Thursday morning. Topic: "Tranquilizing Drugs—Their Uses and Side Effects."

NSTA Activities

Membership Report

The February issue of *The Science Teacher* was mailed to an all-time high of nearly 17,000 members and subscribers. This is indeed gratifying to all those involved in making TST the kind of journal that science teachers want.

Although the distribution of the *Elementary School Science Bulletin* continues to grow (January issue went to nearly 30,000), it has by no means kept pace with the growth in circulation of *The Science Teacher*. We have been told by ESSB readers that it has real value in terms of improving science teaching in grades K-8 and that it is the best instrument of its kind for helping elementary teachers locate, secure, and make use of modern science teaching aids. And yet, literally thousands of elementary teachers do not know it exists. What is lacking? Publicity? We have tried the conventional channels of direct mail and advertising.

If you, as an NSTA member, are convinced that ESSB has value, you can aid elementary teachers by taking it upon yourself to bring ESSB to the attention of your superintendent, elementary school principal, or supervisors in your local school system.

1959 Annual Meeting

The 1959 annual summer meeting of NSTA held in conjunction with the meeting of the Representative Assembly of NEA is scheduled for Wednesday, July 1, in St. Louis, Missouri.

Program Chairman is Mr. Norman R. D. Jones, third president of NSTA (1947-8). Details will follow in later issues of TST. The sessions planned will be of interest to elementary teachers and to those that teach science in junior and senior high schools. Following the above sessions, there will be a luncheon for the participants featuring an address by an eminent scientist or educator.

The annual business meeting of NSTA's Board of Directors will follow immediately after the above sessions. This meeting will be at the Forest Park Hotel in St. Louis and will run through Friday, July 3. Members of the Association attending the earlier meetings and who plan to stay over are invited to come to the business meeting. In addition, any items or suggestions for action, or consideration of the Board may be submitted. Please send such items to Dr. Herbert A. Smith, NSTA headquarters, Washington.

The NSTA Secretary, Mrs. Sylvia Neivert of Bay Ridge High School, Brooklyn, N. Y., is chairman of the Resolutions Committee, and will welcome suggestions from members of NSTA.

Continental Classroom

Although the second semester of the NBC-TV television series under Dr. Harvey E. White has begun, it seems appropriate to remind teachers and interested students of the excellent opportunity this program offers to survey or review modern atomic age physics.

This program has had favorable reactions from the press and education media throughout the country, and even in foreign press comments. It has captured two awards, the Sylvania Award and a special citation by the Edison Foundation. There is no doubt that a way has been opened for future network educational experiments. Under auspices of The American Association of Colleges for Teacher Education (NEA) and The American Council on Education, this program series in classical and modern physics is directed primarily at high school teachers of physics. Dr. Harvey E. White, Professor of Physics, University of California, Berkeley, conducts the classes, together with visiting lecturers. These classes are televised daily, Monday through Friday, from 6:30 a.m. to 7:00 a.m., and began February 6, 1959. This second semester, listed as Atomic and Nuclear Physics, runs to June 1959. Consult your local TV schedule for exact time as some stations may depart from the scheduled time of 6:30 a.m.

NSTA'S Business-Industry Section has been active in promoting participation of teachers and students in this pioneering educational effort. Reports are clearly indicating that the endeavor is not a misguided one, and we urge all of you to become acquainted with the series. For those interested in obtaining additional information, write to the Department of Correspondence Instruction, University Extension, University of California, Berkeley 4.

AO Reports on Teaching with the Microscope

Measurements through the microscope...or how to clock a speeding protozoan

We don't know who he was or when it happened, but the man who made the first measurement and recorded it, probably became the world's first true scientist. Man has been gathering and recording measurement data ever since... virtually nothing escapes his tape measure. The astronomer uses light-years to measure the infinite reaches of the universe; the microscopist uses microns to measure a universe that recedes into infinite smallness; in between lies a vast army of scientists measuring everything on or beneath the earth... indeed, the earth itself... using every conceivable unit of measurement.

The scientific method requires, essentially, the gathering and recording of data... this can be, in itself, an exciting thing. Students can find this to be particularly true as they use the microscope to measure the "unseeable". We hope the following tips on making measurements through the microscope will give your students a new appreciation of this aspect of the scientific method.

MEASUREMENTS THROUGH THE MICROSCOPE

1. ESTIMATE SPECIMEN SIZE

If the field size provided by the objective—eyepiece combination is known, the size of comparatively large specimens can be estimated simply by determining how much of the field the specimen covers. Approximate field sizes provided by the three standard magnifications are as follows:

100X (10X obj., 10X eyepiece) = 1500 microns
430X (43X obj., 10X eyepiece) = 350 microns
970X (97X obj., 10X eyepiece) = 150 microns

To determine field sizes of other low power objective/eyepiece combinations, simply focus on a millimeter scale using oblique illumination (light directed onto surface of scale to reflect off and up into optical system of microscope). You can convert millimeter readings into the microscopists' standard unit of measurement, the micron. One micron is equal to 1/1000 of a millimeter.

2. CROSS-HAIR EYEPIECE

A cross-hair in the eyepiece will mark off the field of view into approximately equal quadrants, thus making it easier to estimate specimen size, particularly if specimen covers less than half the field. Here's how to make a cross-hair disc and insert in eyepiece.

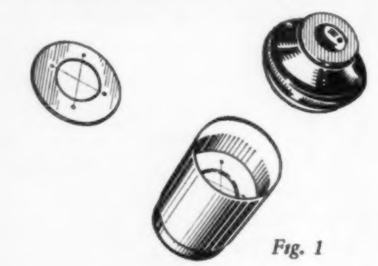


Fig. 1

A. Select a thin washer of proper diameter (approximately ⅞") to fit inside eyepiece. Use human hair (preferably blonde because it is finest) and model airplane cement to fashion a cross-hair over the washer, see fig. 1.

B. Unscrew top lens element from eyepiece. Place washer with cross-hair in eyepiece directly on diaphragm ... replace top lens element.

3. ESTIMATING SPEED OR MOVEMENTS OF LIVE PROTOZOA, ETC.

Interesting exercises into the realms of relativity and mathematics can be worked out using live protozoa. Observe protozoa under low power and use stop watch to calculate time required for one specimen to traverse entire field or portions of field divided by cross-hair. Microscope magnifies size only, not time. Converting microns per second to the familiar miles per hour results in increased student understanding of the various units of measurement.

4. EYEPIECE MICROMETER

Exact measurements can be made by means of a scale, or micrometer disc, placed in the eyepiece. The divisions in the eyepiece micrometer disc have arbitrary length. The apparent length depends upon the total magnification used. Therefore, before the disc can be used to measure a specimen, it must be calibrated for use with each combination of objective and eyepiece against a stage micrometer. A stage micrometer has divisions of true length. The AO Spencer stage micrometer, Catalog Number 400, has a 2mm scale divided into 200 parts . . . each part measuring .01 mm. Every tenth part on the scale is numbered, see fig. 2. If you want complete information about eyepiece micrometers and stage micrometers just write to: Dept. 095 American Optical Company, Instrument Division, Buffalo 15, New York.

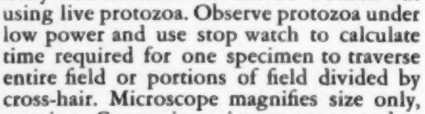


Fig. 2

PROCEDURE

A. Unscrew top lens of the eyepiece... insert eyepiece micrometer, *ruled side down* on the diaphragm within the eyepiece. Replace top lens.

B. Place stage micrometer on microscope stage...focus sharply with 10X objective. Rotate eyepiece and move stage micrometer until both scales are in juxtaposition along the same axis and both scales are even at one end, see fig. 3. Now count the number of arbitrary divisions of the eyepiece micrometer that fall within a specific true distance on the stage micrometer. In fig. 3,

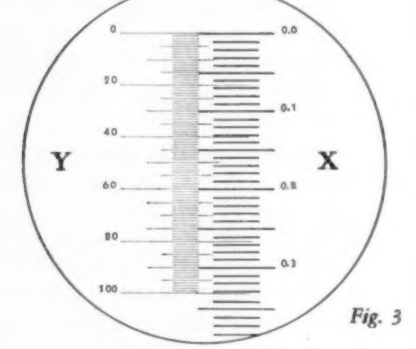


Fig. 3

for example, the first 21 divisions of the eyepiece micrometer (Y) fall within 7 divisions of the stage micrometer (X). We can find the calibration constant (C) simply by dividing the true distance (X) by the number of divisions of the eyepiece micrometer (Y); i.e.:

$$C = \frac{X}{Y}$$

$$C = \frac{7(.01)}{21}$$

$$C = .003 \text{ mm; or 3 microns}$$

Now, using this as an example, if a specimen is measured against the eyepiece micrometer scale and found to span, let us say, 10 divisions, we can determine its size by multiplying the number of divisions it spans by 3 microns, i. e. 30 microns.

NOTE: The eyepiece micrometer must be calibrated at each magnification. Once calibrated, the constant should be noted and then the eyepiece micrometer need not be recalibrated if those same magnifications (and tube length) are used.

$25 For Your Experiment. We will pay $25.00 for each experiment involving either laboratory or stereoscopic microscopes accepted by us for future ads like this one. We're looking for unusual experiments suitable for the high school and junior college level. In the event of similar experiments the one bearing the earliest postmark will be used. The ad containing your experiment will bear your by-line. Write in now!

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CRAVEN . . . from page 107

designed to minimize expenses, was successfully used. This technique requires two glass pie pans, Whatman No. 1 circular filter paper the same diameter as the pans, and a suitable solvent.[4]

The filter paper is prepared by using a pipette to spot its center with extract from the biological system in which tracer studies are being made. The spot should be made as small as possible, dried and respotted until extract containing approximately 10 μg of dry plant material has been added. Dry, tear a small hole in the center of the spot and insert a wick of rolled filter paper.

The spotted filter paper is placed on the lips of an upright pie pan containing a small amount of solvent. A second pie pan is then inverted over the filter paper. The assembly is allowed to set undisturbed until the solvent has diffused nearly to the edge of the filter paper. The paper is then removed, the solvent front marked and the chromatogram dried. A radioautogram may then be made from the chromatogram. After the radioautogram has been produced, the chromatogram may be developed chemically.[5] The Rf values $\left(\frac{\text{movement of band}}{\text{movement of advancing front of liquid}}\right)$ of the separated constituents may be compared with Rf values of various compounds as listed in tables for the particular solvent used.

Precautions

Tracer studies usually require radioactive materials in microcurie quantities. Although radiation on the level permissible under AEC licensing regulations (50 μc C^{14}, 10 μc P^{32}) is not hazardous when properly handled, radioisotopes should at all times be handled with the same respect as pathogenic organisms.

The laboratory worker should be familiar with the characteristics of the isotope he is using, know how to avoid contamination of himself and his laboratory, how to decontaminate his equipment and be familiar with the proper method of disposing of radioactive wastes. These will vary with each isotope.

[4] B.A.W. solvent: Prepared by mixing 4 parts n-butanol, 1 part glacial acetic acid and 5 parts water in a separatory funnel. Use the upper layer.

Phenol solvent: A mixture of 80% phenol and 20% water. *CAUTION—Handle with care.*

[5] Solutions for chemical development of chromatogram:

Amino acid separation: Ninhydrin solution—a 0.2 solution of ninhydrin (triketohydradine hydrate) in water saturated n-butanol.

Sugar separation: Alkaline 3.5 dinitrosalicyclic acid—a solution of 0.5 g of the acid, 4 grams NaOH in 100 ml water.

Generator and Chromatography Chamber (Two 10-inch Pyrex pie plates).

Liquids containing radioisotopes in small quantities may be discarded by pouring down a drain if followed by a thorough rinsing. Solid waste products or equipment contaminated with short half-life isotopes like P^{32} should be allowed to decay for approximately five half lives. The solid wastes are then buried and the equipment washed in detergent and water. Solid waste contaminated with small amounts of C^{14} may be burned in an isolated area. C^{14} contaminated equipment should be soaked in a hydrochloric acid solution under a hood and then washed in a detergent solution.

BLOOM . . . from page 93

The methods used in elementary science should be developed within a framework sufficiently flexible to permit outlets for the interests of both pupils and teachers. It should be a program flexible enough to permit ample opportunity for pupil-teacher planning. It should be the type of program which permits current happenings in science to become an integral part of the science curriculum. Moreover, this flexible curriculum should allow for a spiral approach to understandings as the child matures and passes from grade to grade. The objectives of our science program should be considered as guides for growth rather than as final outcomes. And ample opportunity should be provided for the development of functional information, skills, attitudes, and appreciations.

We should not overlook the great number of beautifully illustrated, scientifically correct science books which are currently being written for the child of elementary school age. The teachers manuals which accompany these books offer many enrichment opportunities. Science experiences are frequently suggested which provide the opportunity for the child to explore, to manipulate, and to experiment with the phenomena of their local environment. These books encourage teachers to plan in terms of the instructional group with which she is working and thus to supplement the curriculum.

General Conclusion

Science is in a key position to make significant contributions to the larger goals of general education. As a body of classified knowledge, science contributes to the understanding of facts, concepts, and principles that function in the adjustment of pupils to life's problems.

The scientific method of investigation contributes skill in identifying, attacking, and solving problems. Attitudes, such as open-mindedness and intellectual honesty are developed by experiences using the methods of science.

At the elementary level the science program has many unique opportunities and responsibilities. It should be the function of each teacher to develop a real activity program in science. A creative teacher supported by an alert administrative staff, strengthened with ample instructional materials, and guided by a flexible curriculum will increase the effectiveness of science instruction in the elementary school.

Book Reviews

THE COMMUNITY OF LIVING THINGS. Etta Schneider Ress, Editor-in-Chief, in cooperation with The National Audubon Society, New York. $32.50 per set. Creative Educational Society, Mankato, Minn. 1956.

This five-volume series is organized around full-page photographs, each with its one-page text. Each volume has several chapters covering various phases of the subject. Throughout there is an emphasis upon ecological relationships and conservation practices. Excellent for upper elementary and junior-high grades as classroom instructional aids or text-supporting references.

1. Field and Meadow. Etta Schneider Ress. 185p. Eighty-five full-page pictures, each with its one-page text, portray the life of plants and animals of a typical open-field community. The plants, insects, cold-blooded animals, birds, and mammals are pictured and described. A final chapter stresses the interrelationships among the living things. Conservation is stressed.

2. Fresh and Salt Water. B. Bartram Cadbury. 240p. Includes 112 photographs covering the plants and animals of various fresh-water and salt-water communities. A chapter is devoted to helping wildlife live.

3. City Parks and Home Gardens. Robert S. Lemmon. 165p. Seventy-eight pictures show the habitats of city parks and home gardens and the birds, mammals, and insects found in them. This book reveals the wealth of living things that may be studied in the urban environment at various seasons, including winter.

4. Forest and Woodland. Stephen Collins. 185p. With 85 photographs. Types of forests are shown with the various plants commonly found. Emphasis is placed upon the animal life: cold-blooded animals, birds, and mammals. A final chapter stresses the relationships between man and forests.

5. The Desert. Alexander B. Klots and Elsie B. Klots. 195p. With 88 photographs. The nature of deserts is portrayed with their peculiar plants, mammals, birds, reptiles, amphibians, and invertebrates. Final chapters cover man's relationship to the desert and deserts as plant and animal communities.

THE FOSSIL BOOK: A RECORD OF PREHISTORIC LIFE. Carroll Lane Fenton and Mildred Adams Fenton. 482p. $12.50. Doubleday and Company, Inc., Garden City, N. Y. 1958.

This book by well-known authors is a major contribution in the field of natural-science writing. It is based upon exhaustive study of known records of life on the North American continent during the past two billion years. The results of extensive research by the authors and others are expertly analyzed and reported. There is a careful separation of fiction and fact, of hypothesis and accepted conclusion.

Here is much more than a book about fossils. The lives and times of ancient creatures are re-created in a fascinating manner. From one-celled forms to modern mammals, from Precambrian times to the Wisconsin glaciation of the Ice Age, there is complete coverage of life as it is known from fossil remains. Separate chapters are devoted to each important group of plants and animals. Two stories unfold simultaneously, the geologic history of the earth and the evolution of life upon it.

The opening chapter tells the nature of fossils and how they have been preserved, followed by an enlightening discussion of what we have learned by studying fossils.

The closing chapter encourages the reader to "read, see, and collect." An extensive list of references is included. At the end is a glossary and index with pronunciations.

The illustrations are superb. They consist of hundreds of extremely clear drawings and black and white photographs and are highlighted by eight plates of color photographs. A special feature is many pictures with carefully labeled parts.

A wide audience will find knowledge and pleasure in this reference. It can be used by the boy who has found his first fossil and the serious student of biology or geology. It should be made available in every school.

ROBERT A. BULLINGTON
Northern Illinois University
DeKalb, Illinois

SCIENCE TEACHING MATERIALS

Prepared by NSTA Teaching Materials Review Committee
Dr. Robert A. Bullington, Chairman
Northern Illinois University, Dekalb

BOOK BRIEFS

HIGH SCHOOL SCIENCE: SOME INSTRUCTIONAL AIDS. F. Dorothy Wood and Charles R. Allen. 64p. 50¢. Field Enterprises Educational Corporation, Merchandise Mart Plaza, Chicago 54, Ill. 1958.

A booklet to aid especially those teachers who have The World Book Encyclopedia. An easy-to-use guide covering biology, chemistry and physics. Divided into topics with study questions and references. A similar book provides assistance to teachers of junior high science.

METALLIC RECTIFIERS AND CRYSTAL DIODES. Theodore Conti. 164p. $2.95. John F. Rider Publisher, Inc., 116 W. 14th St., New York 11, N. Y. 1958.

Describes the basic principle, construction, characteristics and applications of metallic rectifiers and crystal diodes. Well illustrated and easily readable (no mathematics required). The book will benefit laboratory technicians, radio and television servicemen, and radio amateurs as well as engineers and scientists in a different field of specialization. A collection of tables in the appendix will prove useful.

RESEARCH IDEAS FOR YOUNG SCIENTISTS. George Barr. 142p. $3±. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. 1958.

This science book gives original experiments which a student may do in his own environment. It teaches original and practical research. It sets forth experiments in the various areas of science. This book would be adaptable for the junior high school age.

PHYSICAL SCIENCE STUDY GUIDE: A SOCIALLY COOPERATIVE APPROACH TO TEACHING PHYSICAL SCIENCE. Preliminary Edition. Joseph Paige. $2.00. Lyndon Teachers College, Lyndon Center, Vermont. 1958.

The title is descriptive of this excellent outline of a course for prospective teachers of elementary and junior high schools. It is intended for a course of one semester or one quarter in length which combines physical science subject matter with methods and materials. The reviewer enthusiastically suggests that everyone interested in such a course write the author for a sample copy. It is not confined to the use of one textbook. Includes a comprehensive bibliography of 97 books and 25 periodicals, as well as several hundred questions and many suggested experiments.

THE BIOLOGICAL WAY OF THOUGHT. By Morton Beckner. 200p. $6.00. Columbia University Press, New York 27, N. Y. 1959.

This book is the result of an investigation of the philosophical bases of biological science, and of value to all biology teachers who are seriously interested in the backgrounds of their discipline. It provides new thought on such old subjects as the logic of taxonomy, ontogeny and phylogeny, teleology, and natural selection.

THE WORLD OF NITROGEN. Isaac Asimov. 160p. $2.75. Abelard-Schuman, Inc., New York 16, N. Y. 1958.

This book discusses the world of organic compounds containing nitrogen. Topics usually reserved for the college level are clearly treated for teachers and high school students. Topics discussed include amino acids, vitamins, antibiotics, hemoglobin, chlorophyll, and others.

MODERN HIGH SCHOOL PHYSICS. David Vitrogan. 88p. $1.50. Bureau of Publications, Teachers College, Columbia University, New York 27, N. Y. 1959.

This monograph, one in a series prepared by the Science Manpower Project of Teachers College, gives a recommended course of study which may be used in at least two ways: as a course of study to be followed, or as a guide in modernizing the content of existing courses.

LIQUIDS AND GASES. Alexander Efron. 118p. $2.10. John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y. 1958.

Properties of liquids and gases are described with emphasis on the fundamental concepts involved. Laws governing the properties are clearly stated and illustrated with appropriate examples. Surface tension and viscosity are treated only qualitatively and too briefly in chapter I. Physics of the atmosphere is treated quite adequately in chapter V. The information contained in this chapter is very important in daily life today. Suitable for students of high school physics as well as for those general readers who want to satisfy their curiosity through rigorous explanation of the properties of fluids.

PROFESSIONAL READING

"The Unit in Modern Teaching." By A. J. Foy Cross. *Audiovisual Instruction,* 3:168-69. September 1958. Reemphasis of a well-known method of teacher-pupil planning of a total learning process.

Nutrition in the Elementary Schools. By Frances R. Godshall. 112p. $2.75. Harper, New York. 1958. Methods by which principles of nutrition can be developed with young children.

"Elementary Science Activities: Reflection." By Verne N. Rockcastle. *The Instructor,* 68:40-41. December 1958. A group of activities for teaching about reflection.

Academic Achievement of Gifted High School Students. By Leslie J. Nason. 92p. 1958. University of Southern California Press, Los Angeles, Calif.

The Improvement of the Teaching of Science and Mathematics in the Elementary Schools. A study directed by Donald J. Cook. 42p. Free. DePauw University, Greencastle, Ind. Oct. 1958. Results of a committee study financed by a grant from the International Nickel Company. Analyzes elementary science teaching in Indiana and the training of elementary teachers. Evaluates curriculum outlines, textbooks and reference books. Makes recommendations for teacher training and the science curriculum.

Evaluation and the Elementary Curriculum. By H. G. Shane and E. T. McSwain. 436p. $5.25. Henry Holt and Company, New York. 1958. Chapter 12 discusses several types of elementary science programs and suggests instruments and criteria for appraising children's science experiences.

APPARATUS AND EQUIPMENT

Basic Electrical Circuit Kit. Kit consists of line cord, four light sockets, various switches, and "Jiffy-connectors" which fit easily and firmly over terminals, AC ammeter and AC voltmeter. Parts quickly assembled on pegboard. Assembled in sturdy wooden case. Explanatory booklet explains use, gives good experiments, and includes two-color circuit diagrams. This is a handy device for teaching circuitry on either the elementary or secondary level. $29.95. Science Electronics, Inc., 195 Massachusetts Ave., Cambridge 39, Mass.

Radio Circuit Kit. A training set for use in high school science and industrial arts courses. Accompanied by a detailed booklet of instructions and experiments. Easily identified parts can be quickly assembled on templates in 14 basic radio circuits. With headphones, local stations can be received. Powered by 110 AC current. In sturdy wooden carrying case with pegboard work surface top. $49.50. Science Electronics, Inc., 195 Massachusetts Ave., Cambridge 39, Mass.

LAB-VOLT UNIT POWER SYSTEM—MODEL 189. Electrical unit, well-constructed, source of electrical current designed for permanent installation in high school science laboratory tables. This device will give a smooth and continuously variable output voltage from 0-12 volts, either AC or DC, operating from the regular 120 volt AC current system. Service to all individual units may be cut off by a single master switch when the laboratory is being used by other than science classes. A lock-type switch on the front panel permits the instructor to control individual units at any time.

The attractive front panel is 8¾" long and 4" high and provides outlets and cords for the low voltage AC and DC current, an outlet for the 120 volt AC, a pilot light to indicate when the unit is energized. Current output is rated at two amperes. Moderate overloads can be tolerated for several minutes. The unit has been given approval by the Underwriter's laboratories as safe from shock and fire hazard.

In many schools these units should be more satisfactory than a central service panel from the standpoint of initial cost, ease of installation in existing science facilities, flexibility of output, and conservation of space. Other models available. $80. Buck Engineering Company, Inc., 37-41 Marcy Street, Freehold, N. J.

AUDIO-VISUAL AIDS

BASIC SCIENCE TEXTFILMS: BIRD STUDY GROUP. Includes "Looking at Birds," 43 frames; "Nests and Eggs of Birds," 45 frames; "Beaks and Feet of Birds," 40 frames; "Feathers and Flight of Birds," 42 frames; and "Migration of Birds," 43 frames. Designed to accompany Row, Peterson's Unitexts in the Basic Science Education Series. Appropriate for grades four through eight. Contain useful nature study material about birds. In color that is fair. Each frame bears its own caption, but often the name of the bird shown is missing. Good illustrations of basic ideas, but too many exotic birds rather than familiar forms used. Each filmstrip, in color, $6.00. Set, with teaching guide, $27.00. 1958. Society for Visual Education, Inc., 1345 Diversey Parkway, Chicago 14, Ill.

THE METRIC SYSTEM. Using the historical origin as an appropriate introduction, this film presents very clearly the basic principles of the metric system. Inter-relationships between metric measures of length, capacity, and weight are developed. The decimal base and other advantages of the system are shown. Recommended for junior and senior high school. 11 min. Color $110, B&W $60. 1958. Coronet Films, Coronet Building, Chicago 1, Ill.

SIMPLE MACHINES HELP US WORK. An excellent set of color filmstrips well geared to the primary grades. Clear pictures in good color give clear understanding of principles of simple machines.

The six filmstrips are: 1. Levers; 2. Wheels and Axles; 3. Pulleys; 4. Ramps; 5. Wedges; 6. Screws. Single, $4.95; set of six $28.50. The Jam Handy Organization, 2821 E. Grand Boulevard, Detroit 11, Mich.

TANNENBAUM . . . from page 121

techniques which are quite effective. Sometimes a duplicated list of questions to be answered by every person can be the organizing technique of the trip. In other cases, different children or different committees can have specific problems to solve, and from their solutions can come an understanding of the whole process. Again, while the specific questions for the guide need not be prepared, sometimes it is wise to discuss the areas in which questions certainly should be asked and then allow the children to frame the questions themselves when they are at the plant. In any event, whatever technique or organization is used, every trip should have a specific assignment connected with it so that the learning function of the trip is clear to the students.

The guide has certain responsibilities for planning also. He must take the information the teacher gives him about the purpose of the trip and work out the best possible itinerary. The most effective may to do this is to examine the proposed itinerary in the light of the problem which the students are to solve through the trip. Is the trip being taken so that the young people can see the application of a scientific principle to the solution of a technical problem? Then the guide must organize his trip so that he first makes certain that the students have a statement of the principle and then have clear examples of how the principle is applied in his plant or installation. Is the trip being taken to provide new science materials and ideas for the class? Then the guide can let his fancy range—but not too far. One of the most difficult things for guides to do is to remember that the visitors are novices as far as the material to be seen is concerned. And novices can comprehend only a limited number of ideas at a time. Doing a thorough job with a few interesting new ideas is far more effective from the point of view of learning than trying to do a smattering with a great many ideas. So guides should pick out a few of the highlights of their plants of most importance.

As far as the vocational purposes of a trip are concerned, meeting and talking to men who are working in science can be of real help to all young people. Two things need to be watched, however. First, the science personnel should not try to glamorize the work of the scientist. Science is interesting and creative, but it is also arduous and exacting. Young people should learn this. Second, the science personnel should try to give an accurate picture of the requirements of a job. Young people need to make realistic appraisals of what they can do and what they cannot do. And knowing what a profession requires in the way of preparation is important information for making such appraisals and the consequent decisions.

This kind of planning on the part of the guide means that he must take time out from his regular schedule. He cannot simply accept a request for a field trip over the telephone and then do nothing about it until the visiting group arrives. It is better to refuse some trips than to try to take all comers through in a haphazard way. Aside from the benefit to the students, it is well to remember that field trips can be good public relations and good advertising.

During the trip itself, the teacher's role is to act as interpreter for the students. Watching carefully the various responses of the students to the information being presented to them, the teacher can then ask a pertinent question here and put in an extra word of explanation there as he sees the need for such interpolation. Furthermore, it is often necessary for the teacher to help some of the students ask the questions which they have in mind. Certainly, he will have to help interpret these questions to the guide because it is often difficult for young people to use the accurate language of science. If it is at all possible, the teacher should walk alongside of the guide so that as they stop to examine points of interest, the teacher can make sure that the students all can hear what is being said and can do his important interpreting work.

Summary of Trip

A final essential of the trip itself is the summary. At this time, the guide should review the entire trip and the students should have a chance to ask questions about those aspects which puzzle them. Again, the sensitivity of the teacher to the needs of the students is important. He must articulate for those who have difficulty in expressing themselves. He must allow all the students opportunities to ask their questions and must make sure that the very verbal youngsters get their turns but do not monopolize the session.

Back in the classroom there should be further summarization to place a perspective on what has been seen and to find how this material fits into the over-all program of the class. It is here, of course that the specific assignments may be

used. Actually, a thorough summary of a trip will have four parts:

1. An examination of the significant factors of the trip.
2. An examination of the questions which the trip answered.
3. A study of the new questions which the trip raised.
4. A consideration of the relationship between the trip and the total unit being studied.

This kind of summary offers many opportunities for a variety of integrating experiences. English reports on the science trip or studies of the economic overtones of a science phenomena can be very important and useful learning experiences for the students. Certainly there is one follow-up activity that should be included in every trip. A group note of thanks from the class to your host will be most welcome and is an important part of the learning experience.

Hints for Teachers

1. Be sure that the trip is the *best* tool for the goal you are seeking. A color film may be better, for example.

2. Remember that guides are very busy people. Do not ask them to waste their time. Prepare yourself and your students carefully for the trip.

3. Act as the interpreter for your students and phrase those questions which they cannot put into words.

4. Each trip should have a definite assignment related to it. Prepare a list of questions or assign individual reports related to the trip. Try to make them as imaginative as possible. When the students have specific work to do in relations to a trip, it is much more valuable to them, and arouses more interest.

5. In planning your session with the guide, make sure that he knows exactly what your purposes are for taking this trip and how the trip fits into the over-all objectives of the work you are studying.

6. Be careful to summarize the trip and help the students see how it fits into the material that they have been studying. But also make sure that they see some of the ramifications of the trip. A good trip will not only verify what the students have been learning, but will give them new materials and new ideas for further growth and learning.

Hints for Guides

1. Make sure that you can give plenty of time to preparing for your visitors. Your plans should provide for time for a preliminary visit by the teacher as well as the regular visit by the class.

2. Fit your trip into the objectives of the class. When you show the students through the plant (or department), emphasize those aspects of the plant which will help them understand what they have been studying.

3. Make sure that when you stop to describe something all the students can see and hear you. And give them plenty of time to ask questions as you go along.

4. If it is possible, stay near the teacher and let him help you by interpreting the questions the students ask. Answer all of the teacher's questions too. He is asking them to help the students learn.

5. Do not try to show the students too many things. They can grasp and understand only a limited number of new ideas at a time.

6. No matter what else you do, you should summarize the trip for the students when they have completed it. If possible, this should be done in a comfortable place where they can sit and ask you questions.

Conclusion

In conclusion, it is well to remember that field trips, like any other educational tool, are only as useful as the plans and implementations make them. Taking students out to see and to study science as it is being carried on in society can be desirable. But two major values must decide when this is a proper educational procedure. In the first place, the total needs and interests of the students deserve consideration. In the second place, the rights and responsibilities of the hosts in industry, business, and government must be respected. These people are more than willing to cooperate with teachers in arranging trips. But teachers should arrange trips only when they will serve worth-while purposes. And when such trips are arranged, then all concerned must prepare for them carefully and exploit them to give every advantage possible. (Suggested check lists for guides and teachers are listed.)

Reader's Column . . . from page 77

more attention to sharpening up their formulations to cut to a minimum the misconceptions that college teachers will have to slay at a later date.

I am of the opinion that had Dr. Phillips' article contained some indication that he understands the problems that high school teachers face, that his important points would have had greater impact and acceptance.

Hy Ruchlis
672 East 24th Street
Brooklyn 10, N. Y.

November Cover

I have been thinking about the cover on the November 1958 issue of TST. Herewith my interpretations of the scene shown. The rock in the foreground is symbolic of problems of processing and conserving our non-renewable resources. For example, in *The Next Hundred Years* Harrison Brown and Jim Bonner predict the extraction of essential minerals from such rocks as granite. But what about the effect on our standard of living is probably our most critical immediate resource problem, namely, water supply. What are we doing to encourage and stimulate the creation of human resources which will enable us to distill sea water, to solve watershed problems which cannot remain within political boundaries, such as INCODEL. And then there is the problem of water conservation by control of plant transpiration and by the use of chemical film on reservoirs to reduce evaporation.

Finally, the rest of the plant cover in the scene to me symbolizes the plant and soil resource conservation problems of our country. For example, how are we here in southern California going to be able to educate our population to take care of what they have in the way of soil and ground cover before it is all gone? I am referring to such aspects as the nondescript land use problem created by urban sprawl. Here in southern California we lose so much money by careless brush fires for which all of us pay in increased insurance rates and taxes. And the picture suggests to me the possibilities of wise use of such inexhaustible resources as air and sunshine. As H. G. Wells puts it, fifty years from now our successors may regard our casual attitude about polluted air in the same way we look down upon the attitude of those who lived half a century ago with regard to an impure water supply.

As you may know, Sidney Belt at the Educational Testing Service has been developing a conservation test for the 9th graders which tries to embody such interrelated problems and modern problems as I hope I have indicated. The questions on the pilot forms certainly "give one to think."

Elizabeth Hone
Conservation Foundation's Curriculum Center
San Fernando Valley State College, Calif.

GRANTS FOR SUMMER RESEARCH EXPERIENCE

The National Science Foundation announced grants totalling approximately $800,000 to 54 educational institutions for programs in Research Participation for Teacher Training in the summer of 1959. These programs will provide research experience during the summer months for about 550 teachers of science and mathematics; about 400 from secondary schools, and the remaining 150 from junior colleges and small colleges without appropriate research facilities.

Participating teachers will receive stipends of up to $75 per week plus allowances for travel and dependents. These summer research programs will vary in length from six to twelve weeks. Teachers will be chosen by the individual universities and colleges to participate in research programs according to their qualifications. Inquiries and applications should be addressed to the directors of the programs in the list of participating institutions prepared and available from the National Science Foundation. Write them direct and *not* NSTA.

Editor's Note: Again, NSTA may take much credit for having developed and tested an idea that has gained widespread acceptance and support. Through our Future Scientists of America Foundation, an experimental program of summer research assistantships for teachers was carried on for three years in cooperation with about 50 colleges and universities. Now that the idea has blossomed into an $800,000 program of NSF, we have served our catalytic role and shall attend to other matters. Such achievements as this might well be emphasized in urging all science teachers to become members of NSTA. RHC

FROM HECTOR: As noted in the February TST issue under NSTA ACTIVITIES, all requests for publications may now be sent directly to the Publications-Sales Section of the NEA. Two others you may want to order are complete:

1. *STAR '58 Abstracts.* Abraham Raskin, Editor. These are abstracts of the 369 entries in the 1957-8 Science Teacher Achievement Recognition (STAR) awards program, administered under a grant from the U. S. National Cancer Institute. 44p. $1.
2. *Science in the Junior High School.* Prepared by J Ned Bryan. Report of the conference held by NSTA's Future Scientists of America Foundation and co-sponsored by Oregon State College and the Crown Zellerback Foundation; includes recommendations developed by a team of 32 selected teachers. $1.

NOTE: All NSTA publications will be on review at Atlantic City during the Convention, and we will have someone there to also tell you about some of the new ones that will be out this spring. Leave your orders with the NSTA representative there.

SAA: FINAL NOTICE!

Applicants for the Science Achievement Awards program for students are urged to send in their entries now in order to meet the deadline date. All entries must be postmarked not later than MARCH 15.

Due to the time required to process applications for review, no requests for entry forms will be filled after March 8.

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